SCIENCE AND SCIENTIFIC METHOD

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(SCIENCE, TECHNOLOGY AND DEVELOPMENT)

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PREFACE TO THE FOURTH EDITION

The first three editions of this book were sold out within two years. As the book was thoroughly revised and enlarged in the third edition, we have only corrected the minor typographical mistakes in this edition.

AUTHORS.

PREFACE TO THE THIRD EDITION

The warm reception to the first and second edition of this book given by the students and teachers has given us an early opportunity to bring out this third edition. We have availed ourselves of this opportunity for revising the book thoroughly. The book is revised in the light of the orientation course conducted by the University of Bombay, Model Questions supplied to colleges by the University of Bombay and the valuable suggestions from our teachers teaching the subject. Every topic is now treated in simple and lucid language and wherever possible an attempt is made to relate it to everyday life situations. We have adhered strictly to the syllabus. We are quite conscious of the fact that this paper is being taught to the students of arts, commerce and science of second year level and not to the students of philosophy of science. So, in order to sustain the interest of the student, we have avoided unnecessary emphasis on the scientific theories or illustrations in first three chapters. i.e. Nature of Science, Presuppositions of Science and Scientific Method.

Our approach to the teaching of the subject is one of making the student an active participant in the learning process. In keeping with this approach, we have provided at the end of every chapter precise summary and a set of exercises.

Our thanks are due to our friends from teaching fraternity who made valuable suggestions. Further suggestions, if any, from teachers, and students to improve the utility of this book, will be gratefully received.

AUTHORS.

PREFACE TO THE FIRST EDITION

The present book has been written in accordance with syllabus and the guidelines given in the orientation course conducted by the University of Bombay in November, 1978. As the original manuscript had to be revised in the light of guidelines, the publication of the second section of the book was delayed. However, the present Volume, which has been brought up-to-date in the light of the guidelines and the experience gained in the teaching of the subject, will, be are confident, meet the genuine requirements of the students :

Foundation Course, Paper II, is a compulsory paper, for Arts, Science and Commerce. It consists of two sections : (1) Science and Scientific Method and (2) Science, Technology and Development. This is an "awareness" course and not an information oriented course. We have, therefore, taken considerable care in presenting the matter in a simple, non-technical language. While describing the increasing impact of science and technolygy on society, we have avoided technicalities, for we are aware of the fact that students do not have an adequate background of the philosophy of science and social sciences. To make the book lucid and readable and at the same time, to be comprehensive are the aims which the authors have kept in their minds.

The authors hope that students will find in this book valuable aid to an understanding of the Foundation Course—Part-II.

August, 1978.
Bombay.

AUTHORS.

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ORIGIN OF SCIENCE

The history of science is very long. Its roots go back to the beginning of civilisation or the origin of human society. Long before the beginning of modern civilisation, men had acquired reliable knowledge about their environment. For example, they discovered fire; they knew the substances that nourish bodies; they developed the skill of making clothes and utensils; similarly, they invented arts of tilling the soil. We can further say that many of the existing special sciences have grown out of the practical concerns of daily living. For example, geometry has grown out of the problems of measuring and surveying fields; mechanics has grown out of problems raised by the architectural and military arts; the problem of human health and animal husbandry gave rise to Biology; Economics has grown out of the problems of household and political management. For acquiring the knowledge about the various things and also to acquire skill, men had not to wait upon the advent of modern science and its methods. Men in the past, acquired reliable knowledge by using their "native gifts" and by using "common sense" method. If it is so, the issue regarding the special characteristics of science must be carefully considered.

SCIENCE AND COMMON SENSE

According to Thomas Huxley, "science is nothing but trained and organized common sense." Its distinctive characteristic is its critical and accurate observation and description of things and events. To differentiate between the common sense and science, it is usual to treat science as simply "organized" or "classified" common sense. Let us see whether this description is appropriate for the use of the word science as distinguished from the common sense.

It is true that the sciences are organized bodies of knowledge and classification of their materials into significant type is an indispensable task. For example, classification of living things into species is indispensable in Biology. But the label "organised" or "classified" common sense does not give adequate expression to the difference between science and common sense. **The above description does not specify what kind of organization or classification is characteristic of the science.**

The common sense information may be accurate enough within certain limits but there is no explanation of why the facts are as alleged. The common sense knowledge about the wheel is without the knowledge of the frictional forces. **The common sense knowledge lacks good reason in support of its explanation.** For example, medicinal properties of herbs like the foxglove have been recognised for centuries. Even if the explanation is given that foxglove is a cardiac stimulant, it is explained in terms of the similarity in shape of the flower and the human heart. In other words, common sense explanations are based on superficial resemblances and characteristics. They are frequently made without critical tests of their relevance to the facts. **Common sense judgement may be apparently accurate but its reasons are wrong.**

Science gives explanations which are at once systematic and controlled by factual evidence. The organisation and classification of knowledge is based on the explanatory principles. More specifically, the sciences seek to discover and to formulate in general terms the conditions under which events of various sorts occur. The statements of such determining conditions are the explanations of the corresponding happenings. Thus the goal of explanation can be achieved only by distin-

guishing or isolating certain properties in the subject-matter studied and by ascertaining the repeatable patterns of dependence in which these properties stand to one another.

Common sense knowledge is concerned with the things within which its beliefs are valued or its practices are successful because they are usually products of tradition and routine habit. In common sense knowledge there is no awareness of the reasons of its successful operation. The aim of systematic science is to remove this sort of incompleteness but common sense knowledge suffers from a sense of incompleteness. So the sciences introduce refinements into ordinary conceptions by the very process of exhibiting the systematic connection of propositions about matters of common sense knowledge.

Common sense knowledge is concerned with the things that men happen to value. The relation of events to one another, independently of their incidence upon specific human concerns, are not systematically noticed and explored. On the contrary, the occurrence of conflicts between judgements is one of the stimuli to the development of science. By introducing a systematic explanation of facts, by ascertaining the conditions and consequences of events, by exhibiting the logical relations of propositions to one another, the sciences strike at the sources of such conflicts.

The language in which common sense knowledge is formulated and transmitted may be quite vague and the terms of ordinary speech may lack a relevant degree of specificity. So experimental control of common sense beliefs is frequently difficult. On the contrary, the scientific statements make use of highly abstracted concepts.

In the primitive men's achievements and transmission of the basic techniques and knowledge, there was an element of 'science'. Their attempts at the understanding, prediction and control of nature went hand in hand. Moreover each of the tasks involved, in its own way, a direct contact with the uncontrolled world of nature. The regularities of the natural world such as the cycle of the seasons, rising and setting of the sun and the revolutions of planets were important for huntsmen and farmer alike. Irregular phenomenon say, natural disasters such as floods and earthquakes, storms and droughts.

eclipses and rainbows called for an understanding of their predictions. But the primitive men were dominated by the belief that all these events were caused by personal agents 'gods' who needed to be honoured and pleased. In other words, they were unaware of the sharp distinction between religion, magic, technology and science. As all these terms need detail clarification, we shall consider the various interpretations of these terms beginning from the word science.

WHAT IS SCIENCE?

The word **science** comes from the Latin word **scientia** which means knowledge. At one time, the word science was used to denote all systematic studies or organized bodies of knowledge. Now, if we accept this definition, a railway time-table, which is accurate, verifiable and organized in a definite order will have to be regarded as a book of science. In other words, the above definition is too broad and does not bring out the essential characteristics of science.

According to W. C. Dampier, "Science may be defined as ordered knowledge of natural phenomena and the rational study of the relations between the concepts in which those phenomena are expressed." According to Conant, "Science is an interconnected series of concepts and conceptual schemes that have developed as a result of experimentation and observation." In the early days of modern science, Francis Bacon defined science as a revolution against superstition and prejudice. He regarded science as the basis of true and securely founded facts Karl Popper suggested that science is a condition of perpetual revolution. According to him, a sceintific theory is not scientific unless it is inherently capable of replacement by further empirical evidence. In other words, science is an active process that can be followed through the ages. But scientific activity is never complete. The area of science is vast and diverse. The techniques used in that great area get refined with the passage of time Moreover, science interferes with other spheres of man's intellectual and social activity. It is, therefore, difficult to define the word "science" and bring all kinds of scientific knowledge under one formula. The growth of science in modern times has rendered it difficult of definition. It is, however, possible to describe in general, the nature of science.

NATURE OF SCIENCE

The fundamental character of science is that it is **a method of approach** to the entire empirical world. This approach is not aimed at persuasion. The approach of science is aimed at analysis. It permits a scientist to show the relationship between the empirically verifiable facts or ordering them in some meaningful way. The development of science can be considered as a constant interplay between a theory and facts.

Science has two aspects: the first aspect is practical and the second is theoretical or pure. These two aspects are inseparable Science is a single whole and its division into various branches is largely conventional. The range and complexity of science is so great that mankind knows only a fraction of it. The laws and principles discovered in scientific investigation have a value apart from any narrow utility they may possess. Science is knowledge or pure learning and so it is an end in itself. The intrinsic value of science is the satisfaction of curiosity, the fulfilment of the desire to know. Albert Einstein says, "There exists a passion for comprehension just as there exists a passion for music. Without this passion, there would be neither mathematics nor natural science." Science does not merely give the power to satisfy one's various practical needs. It is itself a direct satisfaction of the desire to know. Some philosophers say that there is no such thing as a purely disinterested desire of knowledge. According to them men have only practical wants. So science is an instrument which is used for the control of nature and thereby the satisfaction of practical wants. We cannot deny that utility has proved to be a great stimulant for the development of science, but we may ask, what is the scientist's motive in putting out theory after theory? They put out theories because they enjoy comprehending. In other words, science has purely disinterested desire for knowledge as its goal and it is not directly concerned with values.

As science has evolved, so has its meaning. It is multidimensional and continuous. Science is dynamic. It only seeks to discover. Through the use of science we are more likely to obtain the correct answers to questions and better solutions to problems. The superiority of scientific inquiry derives from the fact that it is controlled. Perfect control is an ideal which is approx-

imated more and more closely with the advance of science. But it is never attained. In short, science is a never-ending search for judgements to which the universal assent of experts may be obtained. It is characterized by the goals of self-perpetuation and self-improvement.

ORDER AND SYSTEMS

Empirical sciences deal with the sensible facts. The sensible facts must be collected and put together for scientific investigation. But there must be some definite plan to put them together or to arrange them into some order. So in an orderly arrangement of facts there is some plan or some definite purpose. In an orderly arrangement of facts, the scientist determines the position of each fact on the basis of the nature of order that is in his mind. There are mainly four types of order or four successive stages of the scientific development. These four types of order are: (1) The Classificatory Order, (2) The Causal Order, (3) Mathematically Expressed Uniformities, and (4) The Order of Theories.

(1) **The Classificatory Order:** A scientist does not merely observe facts. He selects them because he has definite purpose in doing so. But even after selecting the facts he must arrange them according to his plan. The same fact may be classified differently, depending upon the purpose or the plan of the scientist. Even in our day-to-day life we classify the things to explain the facts. For example, we may classify the trees into fruits-bearing trees and those other than fruit-bearing trees. So we have discovered an order in the nature and we have explained a fact. The scientist does this task deliberately. So his classification is more purposive and it is based on certain principles. It enables him to explain or to give reasons for putting the facts in a definite order. But classification being at the beginning of the scientists' activity, it represents a low level of order. But it is an essential stage in the development of science.

(2) **The Causal Order:** There are some fields of scientific inquiry in which the explanation is given in terms of cause and effect. But the search of cause is relevant only in a few fields of science. For example, in the applied sciences such as medicine and engineering and in the social sciences, the expla-

nations show the causal order in the facts. In modern times the notion of causation has undergone a radical change. It can hardly be used in the physical sciences.

(3) **Mathematical Order:** All the advanced sciences make use of mathematics. The laws in the advanced sciences have to be expressed mathematically because there is economy in doing so. Moreover, it is easier for an expert to understand the quantitative relationship shown by mathematical expressions rather than qualitative expression of the laws in the advanced sciences. Mathematics is often used as a tool in all advance sciences because they are largely concerned with quantitatitve relations. So the mathematical order plays a very important role in the modern time.

(4) **The Order of Theories:** On the basis of a theory many generalization can be deduced. A theory may explain many facts—within its scope and discover a kind of order. For example. Einstein's theory of relativity can explain Newton's law of gravitation which in turn explains many other natural phenomena.

The notion of system lies at the basis of all science. The ideal of science is to achieve a systematic interconnection of facts. Mere collèction of information cannot make a system. By constructing a system the extent and accuracy of the collected information is increased. In other words the number of unconnected propositions and the number of proposition—for which there is no evidence are at a minimum in a system. In a system, the requirements of simplicity are satisfied in a high degree because whatever is capable of proof is only proved in it. The ideal of system requires this condition. So it is the systematic character of scientific theories which gives high probabilities to the various individual proposition of a science. The system-building in science is a continuous activity. If the system is more general, it introduces a higher type of order.

CHARACTERISTICS OF SCIENTIFIC KNOWLEDGE

Scientific knowledge is organised factual knowledge. It is arrived at by the use of scientific methods and techniques. The scientific knowledge is objective knowledge. It is free from prejudices and subjectivity and relativity. This is one

of the reasons that scientist can submit his knowledge for verification to anybody interested in knowing it. Scientific knowledge can be verified by observation and experiments because it expresses the repeated patterns of the occurrence of facts. Scientific knowledge is universal and open for verification. As the concepts used in scientific knowledge are precise, it can be communicated in the scientific language through the scientific journals, seminars and other available modes of communications between the different scientists all over the world. In the advanced sciences, scientific knowledge is mostly expressed in terms and concepts of mathematics.

As the data of scientific investigation is not fixed and new data and knowledge is increasing day by day, no scientist can claim that the scientific knowledge which is supposed to be precise today will permanently be treated as certain. So scientific knowledge is tentative and probable. The scientist makes efforts to correct it in the light of new phenomena. The new hypothesis and theories are put forth and the old hypotheses are rejected. In the light of such developments scientist reformulates his hypothesis and correlates it with the new facts. So scientific knowledge is self-corrective. This is the major reason for progressive nature of science. The advancement in sciences take place rapidly due to its inherent characteristic of perpetuation and self-improvement. This does not mean that only when new hypothesis or facts are brought to the notice of scientists, he necessarily rejects his hypothesis. On the contrary, he may look back for a discarded hypothesis which may be correct in the light of the new facts.

SCIENTIFIC AND NON-SCIENTIFIC KNOWLEDGE

Science is a process of inquiry i.e. it is a procedure for (a) answering questions, (b) solving problems, and (c) developing more effective procedures for answering questions and solving problems. What we call 'common sense' inquiry is a non-scientific inquiry. **The difference between the scientific and non scientific inquiry lie either in subject matter or in method, or both.** Common sense and other non-scientific inquiry is concerned with more immediate and practical problems than is science. However applied science does deal with immediate and

pressing problems. On the other hand philosophic inquiry, is frequently directed toward problems which are neither immediate nor pressing. John Dewey observed, "The problem of the relation of the domain of common sense to that of science has notoriously taken the form of opposition of the qualitative to the non-qualitative or the quantitative. There is half truth in the general observation that common sense inquiry is qualitatively oriented, whereas, scientific inquiry is quantitatively oriented. The distinction between qualitative and quantitative inquiry breaks down when we consider the outstanding scientific achievement of the nineteenth century theory of evolution. We shall find that this theory has nothing to do with measurement. It is concerned with quantitative changes and treats it qualitatively. Moreover, there are obvious instances of common sense inquiry which are quantitatively oriented.

Science is a body of knowledge. But what is important is the process which generates this knowledge rather than the knowledge itself. The superiority of the scientific process of inquiry derives from the fact that it is controlled. A process is controlled to the extent that it is efficiently directed towards the attainment of desired objectives. Perfect control is an ideal which is approximated more and more closely with the advance of science, but it is never attained. Every inquiry has some controlled and some uncontrolled aspects. Consequently, there are many gradations of inquiry rather than the simple dichotomy: scientific and non-scientific.

It should be realized that much of the common knowledge and common sense that provide the basis on which to-day's decisions are based are the products of yesterday's science. Science is also characterized by the goals of self-perpetuation and self-improvement. Its ideal is to increase without limit our knowledge and our ability to answer questions and solve problems.

Experimentation is sometimes taken to be identical with scientific research. Not all scientific research, however, involves experimentation. Experimentation as conceived in the 19th century involved the physical manipulation of objects, events and their properties. Physical manipulation was taken to be identical with control. But controlled inquiry can be conducted without physical manipulation. For example, consider astro-

nomy. Upto now the astronomer has not been able to manipulate physically the objects of his study. The products of scientific inquiry are: (1) a body of information and knowledge and (2) a body of procedures which enables us to add to this body of information and knowledge.

SCIENCE AND MAGIC

Magical beliefs and practices tend to persist even in the industrial societies. They were widespread in primitive societies. According to E. B. Taylor, magic developed from the thought processes of primitive man by means of association of ideas becoming organised into an elaborate and systematic pseudo-science. **But magic is often thought of as fraudulent art which pretends to an occult control of nature or of spirits and the falsity of its claims is emphasised.** Although the immediate context of magic and science may be the same, their procedures are different. Even if a man has good empirical knowledge, his knowledge, skill and technique cannot cope up with certain conditions and hence he has to resort to magic. Even when failure of magic is admitted in a particular. case; men often protect the institution as a whole by explaining the failure as due to even more powerful countermagic.

Magic is based on the assumption that words and actions technically unrelated to a phenomenon can exert a physical effect. So it is based on the wrong notion of "connections" in nature. **There is a superficial resemblance between magic and science viz. the belief that there are connections in nature. Everything is caused in nature.** But in magic coincidences are considered as necessary connection. Both magic and science try to discover the mysteries of nature. However, the aim of magic in discovering the mysteries of nature is to control the nature for the purposes and ends of human beings. Although scientific knowledge can be used in practical life, primarily it aims at theoretical knowledge.

SCIENCE AND RELIGION

Religion has been one of the dominant concerns of mankind. It developed much earlier than science. It has been more widespread than all other activities. It grew out of man's will

to live. Perhaps, it grew out of man's quest for the completion and fulfilment of life. It is supposed to be primarily a set of beliefs. For example, for a long time, man believed that he lived on a body of matter that was the center of everything created by God. Even in the medieval time man was supposed to be the purpose and end product of creation, the center of the universe and of all living beings. But now we know that the earth is only a small part of the vast cosmos and is far from the center. Even today in the advanced countries, people use the notions of heavenly bodies and their control on the human beings. For example. astrology which is a pseudoscience is based on the belief that the motions of the planets and stars are controlling factors in an individual's life. The impact of Astrology on human beings can be seen as far back as our written records show and even today we find its tremendous influence over the mankind living in scientifically advanced countries. For example. in the U.S. alone an amount of over 125 million dollars a year is spent on astrological literature and services.

Hegel. the German philosopher and Taylor. the anthropologist have interpreted religion as belief. But they admit that **intellect** and **explanation** are essential to any high religion or it will lose its appeal. According to Schleiermaker a German theologian. pure religion is pure feeling of absolute dependence on God. So from this point of view emotional element is supposed to be dominant in religion. But unless emotions are accompanied and guided by intellect, they will be in great danger. We can say that a religion is more than mere belief or an understanding of something. It implies the reaction of a man's whole being to that on which he feels dependent. Religious life is the life lived in conviction that "what is highest in spirit is deepest in nature".

Religion implies devotion and an object of worship. So devotion and worship have central place in religion, on the contrary science gives importance to disinterested knowledge. The main concerns of religion are harmony, adjustment, commitment, worship, peace, righteousness, salvation and God. As religion stresses personal adjustment and commitment, it differs from science and philosophy. Religious people think that their convictions are fundamentally true. But science being a

continuous process of inquiry is ever changing and aims at self-improvement.

SCIENCE AND PHILOSOPHY

Before about a century ago most of what we today call science was called natural philosophy. Philosophic inquiry and scientific inquiry were not differentiated from each other, at least popularly, until about the middle of the nineteenth century. In the days when all scientists were philosophers and most philosophers were scientists a great deal of attention was given to the way in which knowledge was acquired. Inquiry into this procedure which was mere philosophically than scientifically oriented was alternately called epistemology and the theory of knowledge.

Philosophy is an attempt to understand the world, its meaning and its value. Its field is broad and inclusive. It attempts to answer questions about life, its beginning and ends and also everything that is 'experienced' by human beings. It makes use of the facts and descriptive materials presented by specialised fields of study but it goes beyond description to inquire into the nature, the value and the possibilities of things. Its goals are understanding and wisdom. Philosophy seeks to unify the results of the sciences and insights of moral philosophy, aesthetics and religion. Philosophers make attempt to give a "reasoned conception of the universe and of man's place in it".

Philosophy and science have much in common. Both grow out of the reflective, inquiring attitude. Both philosophy and science are motivated by an impartial love of truth. But sciences deal with special or restricted fields. The purpose of various sciences is to describe the world so that it may be interpreted in exact or mathematical terms and then if possible to control it mechanically. The goals of science are description, prediction, experimentation and control.

With the separation of science from philosophy there came an increased awareness of the superiority of the methods and techniques of science for acquiring knowledge. Consequently, those who were concerned with the theory of knowledge turned more and more to the analysis of scientific method. Since this inquiry was itself largely speculative in character, it remained

philosophic and came to be known as philosophy of science. Philosophy of science has also interest in conceptual analysis and examination of assumption concerning reality and synthesis of various branches of science into one consistent view of reality.

Scientists and philosophers engage in philosophy of science, which is one of the few remaining grounds on which they meet. But even this ground has been shirking as the study of scientific method itself has become less and less speculative and more and more scientific.

SCIENCE AND TECHNOLOGY

In a highly complex industrial society much of man's life is passed in an environment which is man made. The speed of scientific and technological development can be known by considering a simple fact that the first powered aeroplane flight by Wright Brothers in 1903 was just over half the length of the modern jumbo jet. (In 1903 the first Wright Brothers plane flew 120 feet and it carried the pilot only. The Boeing 747 Jumbo jet of 1970 is 230 feet long and has a flying range of over 3500 miles. it can carry 490 passengers). Hence to understand our ever changing society is a necessity. The understanding of our society will enable us to survive satisfactorily within it and prepare us for changing it where it is unsatisfactory. So it is important to understand technology.

Science is intimately linked with modern technology. Two are indivisible and technology is a foundation of contemporary society. The activities of scientists are to explain the natural and human world, those of technologists, to use these explanations so as to manipulate this world, to use its properties in order to build new objects, machines or devices. But there is continuity between these activities. Technology is systematic knowledge and action, usually of industrial processes but applicable to any recurrent activity. Science deals with man's understanding of the real world around him, the inherent properties of space, matter, energy and their interaction. Technology deals with the tools and technique for carrying out the plans. designs and in achieving the desired objectives by using the available means or by discovering the new means.

DIFFERENT USES OF THE WORDS SCIENCE AND DISCIPLINE

The word science may be used in two different senses. viz. (1) comprehensive sense and (2) strict sense. **In comprehensive sense, the word science means a body of ordered knowledge or the body of knowledge systematized by following a method.** Even in the comprehensive use of the word science, importance is given for **following a method.** In this sense we can say that Logic, Mathematics, Physics, Biology, Economics, Psychology, Bio-chemistry, Medical—Engineering are sciences. **But if the word science is used in its strict sense we will have to restrict the use of the word science to that body of systematically organized factual knowledge which is obtained by the use of scientific method'.** In this restricted sense of the word science, we consider the facts of experience. Such sciences are called empirical sciences or natural sciences. So we cannot treat Logic and Mathematics as sciences when we use the word science in its restricted sense. The reason is obvious. Logic and Mathematics are not based on the facts of experience, although to understand the facts of experience we make use of both Logic and Mathematics. The method used in these sciences is deductive i.e. the method of drawing (deducting) the conclusions on the basis of certain accepted principles or axioms. The sciences which do not need facts for ordering the knowledge are called formal sciences. **So Logic and Mathematics are the formal sciences whereas, physics, Biology, Chemistry etc., are the empirical sciences.** In modern times, generally the use of the word science, implies empirical science. But traditionally, the word science was used for both the formal and empirical disciplines of knowledge. **So when Logic and Mathematics are regarded as sciences it is quite clear that the word science is used in a very broad or comprehensive sense.** Due to the impact of empirical sciences some critics insist on using clear and exact concepts Although this stage must be attained in the age of science and technology, our languages are not rich enough to express everything precisely. Sometimes **Logic and Mathematics are described as formal disciplines to distinguish them from the empirical sciences.**

In this connection let us consider the views of John G Kemeny. His views are summarized below. The word science is ambiguous. On the one hand it may be applied to an extremely **general type of intellectual** activity to include a science of Logic, science of mathematics and science of Ethics. All these scholarly activities have very little relation to each other. On the other hand, in a narrow sense, the word science may include the fields like Physics, Chemistry, Biology or Social Sciences. We may call these sciences as empirical sciences because they are based on sensible facts or experiences.

Although the empirical sciences differ from each other fundamentally they agree in the way in they accept their theories. This is a very important point of distinction between the empirical sciences and the other intellectual activities. Moreover, in the empirical sciences, the theories are led back to factual observations. They arise out of factual observations and they have their final justification in further observations. This is the common tie uniting various types of scientific activities which is not shared by other types of intellectual pursuits.

Out of the various intellectual activities, Logic and Mathematics play very important role in the empirical sciences. But if the word science is to be used in the narrow sense as stated above, mathematics will have to be regarded as a tool of sciences. It merely becomes a kind of intellectual activity or a kind of discipline. On this ground John G. Kemeny does not regard mathematics as a science. It is a tool or an intellectual activity or a discipline. Traditionally, mathematics was often classified as a science, simply because applied mathematics was often used in the sciences. Before arriving at a conclusion on this issue we shall briefly consider the nature of Logic and mathematics. The best and brief way of showing relationship between them is to explain these terms in the words of Bertrand Russell. According to him, "Mathematics and Logic have deveed in modern times: Logic has become more mathematical and mathematics has become more logical. The consequence is that it has now become wholly impossible to draw a line between the two, in fact, the two are one. They differ as boy and man; Logic is the youth of Mathematics and Mathematics is the mankind of Logic".

Logic studies the meaning of logical constants and the way they enter into forms of proposition. Mathematics is a study of the forms of arguments and that it is the most general branch of knowledge. It is no more than an analysis of the meaning of words, and a study of forms of arguments. Both logic and mathematics study forms and tell us what follows from the meaning of the terms used. Then they yield true analytic propositions. As they analyse the meaning of words, they bring us facts that are new to us, i.e. facts which we did not realize we possessed.

Logic and mathematics have been regarded as formal disciplines in order to distinguish them from empirical sciences. But the word discipline is also a broad term like the word science, if it is used in the comprehensive sense. Hence the use of the word discipline is as defective as the use of the word science. As we are primarily concerned with the empirical sciences, and it is only in this sense, the word science is used in the modern times. we shall for the sake of our convenience and in order to avoid confusion use the description formal disciplines for mathematics and logic.

DISTINCTION BETWEEN SCIENCE AND FORMAL DISCIPLINE

The distinction can be made between the science and formal disciplines as follows:

Science is a factual body of knowledge, whereas formal disciplines are not based on the facts of experience or observable facts. Science seeks the facts, describes and explains them and predicts the occurrences regarding the experimental facts. On the contrary formal disciplines construct deductive systems. Axiomatic Systems in Logic and the proofs of theorems as given in Geometry are based on certain accepted principles or axioms. Once the principles or axioms are accepted as true, other true propositions of the system can be stated.

Science begins with facts and also ends with facts but formal disciplines begin with the axioms and end with the deducible necessary propositions. The conclusions of science are contingent propositions or the propositions based on experience. Such propositions may be true today, if they agree with facts

and false in future if they do not agree with the facts. On the contrary, the conclusions of formal disciplines are necessary propositions and hence they are certain. They are necessarily true because they are derived from the truth of their principles or axioms.

The method of formal disciplines is deductive i.e. they deduce the propositions on the basis of certain axioms and accepted definitions and rules of decision procedures. On the contrary, the method of science is the verifiability of facts. There may be elements of deductive method when the verification of hypothesis (or a proposed theory) takes place or the consequences of hypothesis are determined. But the deduction is not as pure as it is in the formal disciplines. In the science there is no escape from the observation of facts and hence the deduction cannot be pure.

NATURAL SCIENCES AND SOCIAL SCIENCES

The different branches of scientific inquiry may be divided into two major groups, viz. the empirical and the non-empirical. The empirical sciences depend on the empirical evidence which is not essential for the non-empirical sciences. For example, the non-empirical sciences such as Logic or Mathematics are not dependent on the essential reference to empirical findings. The empirical sciences are often divided into the natural sciences and the social sciences. But there is no general agreement on precisely where the dividing line is to be drawn.

The natural sciences deal with the material world and consider the structure and properties of matter. The social sciences, however, study the structure and properties of human groups. They study the way in which individuals interact with one another and with their environment. Usually, the natural sciences include physics, chemistry, biology and their border areas. The social sciences include sociology, political science, anthropology, economics and related disciplines. Psychology is said to overlap both. Perhaps the earliest of the social sciences is politics, for the most important of human groups in general has been the state. Politics is followed by economics, history, jurisprudence, anthropology, etc. A study of early man, historic and pre-historic, became possible only after the rise of the natural sciences like geology. Social sciences are the academic discip-

lines which deal with men in their social context. The social sciences overlap each other. They also overlap the natural and human sciences on the one hand and art on the other.

The words 'social' and 'natural' are so distinct that they suggest that the subject-matters denoted by them must be mutually exclusive. But we cannot forget the fact that social facts and human beings are located in physical time and space. If we deprive the social facts and the human beings of their physical elements or dimensions, they will lose their usual meaning and cease to have reference to anything existing. So, we must not conceive the social and the natural sciences as mutually exclusive. They are rather the parts of the same subject-matter from different points of view. The social life of human beings is within the realm of natural events, but certain distinctive characteristics of social life make it the object of a group of special studies. Although the social phenomena are conditioned by the biological processes of the human organism, they are not merely biogenic. They are related to the rules or ends of the community. We cannot, therefore, say that the physical elements of the social facts are necessary and sufficient conditions of social acts.

Social sciences deal with volitional conduct and judgements of value, while the natural sciences deal with causal relations or in discovering the laws of nature. Social sciences deal with concrete historical happenings while the natural sciences deal with abstract or repeatable aspect of natural events. But the discriptions of social facts are made in terms of purposes or final cause. So the causal relations cannot be eliminated from social consideration.

It is the aim of all natural sciences to rise above the historical stage and to become theoretical, that is, to attain the form of theory or system in which all propositions are logically or mathematically connected by laws or principles. The subject-matter of social sciences is inherently more complicated in the sense that in them we have more variables to deal with than in physics or chemistry. Maurice Duverger says, "In the world today, the social sciences have even more important application than nuclear physics. The techniques of propaganda in totalitarian states, advertising in capitalist countries, public re-

lations, revolutionary war and psychological actions have transformed human life even more than nuclear fission."

In the natural sciences progress in theory preceds practical application, whereas the reverse is the case in the social sciences, where practice seems more advanced than theory. This is quite natural because the social sciences deal with behaviour of human beings who have free will and therefore cannot be controlled like matter. The facts of natural sciences can be experimented upon, under controlled conditions. Hence, the natural sciences are exact but social sciences are not.

PURE AND APPLIED SCIENCE

The distinction between pure and applied science plays a central role in most contemporary discussion of science. The distinction is difficult, if not possible to make precise. Pure science and applied science represent ranges on a scale and that a point of separation is difficult to specify. It is necessarily somewhat arbitrary, because we cannot predict applicability of scientific research.

Pure research is frequently characterised as that which is conducted 'for its own sake.' For example, according to Norman Campbell "First, science is a body of useful and practical knowledge and a method of obtaining it. It is science of this form which played so large a part in the destruction of war, and it is claimed, should play an equally large part in the beneficient restoration of peace ... In its second form or aspect, science has nothing to do with practical life, and cannot affect it, except in the most indirect manner, for good or for ill. Science of this form is a pure intellectual story. It's aim is to satisfy the needs of the mind and not those of the body, it appeals to nothing but the disinterested curiosity of mankind."

Pure sciences aim at understanding and explaining the nature of phenomena. Applied sciences aim at controlling the events. When the scientific knowledge is applied to the industrial processes, new techniques and technologies develop. For example, applied ecology deals with man's activities in managing natural resources. It is the management based upon a knowledge of basic ecology and upon how man's efforts can change actions, reactions, and interactions with the communities of

plants and animal. An ecological approach is implicit in all agriculture, forestry, range management, wild life management, fisheries management and other aspects of natural resource management. The term applied ecology is usually restricted, however, to management practices specifically based upon ecological science. Ecology is a study of the relation of organisms to their environment or in more simple terms, environmental biology. It is the study of the structure and function of nature. It is one of the basic divisions of biology.

LIMITATIONS OF SCIENCE

Just as scientists do not agree among themselves about the nature of science, they do not agree about the limitations of science. Hence, a few limitations have been pointed out below.

1. **Science can discover only that which is discoverable by the techniques available at a particular time.** So scientifically valid knowledge is that knowledge which scientific instruments and methods are capable of giving and nothing else. For example, when the elephant is weighed two tons, the idea of elephant disappears and a mass of two tons takes its place. Sir Arthur S. Eddington has pointed out that when we state the properties of a body in physical quantities, we are indicating the response of various measuring instruments to the body and nothing more.

2. **No scientific classification includes everything in the subject being classified.** Classification is one of the fundamental bases of scientific knowledge and it gives valuable information. But the kind of classification depends on the purpose of the scientists. Same thing may be classified in different ways. For example, building may be classified according to location, type or valuation.

3. **If we analyse an object, its elements or simple units are not more real than the object or event with which we began.** Scientific method is concerned with the analysis but in doing so the qualities of whole may remain absent in the parts in which it is analysed or divided into its constituent elements. Scientific analyses and explanations do not alter the facts of experience. For example, water is composed of hydrogen and oxygen which are gases with all the qualities and properties of gases. But

these gases will not quench thirst or freeze at zero degrees centigrade. But all these thing can be seen in the water. So when we analyse things into simple units, it is a mistake to believe that these units are more 'real' than the whole of which they were parts, or of the same kind of reality as the whole. The real nature of thing is found as much in wholes and in qualities as in the elements or parts. The world which science gives us may be a real world but it is not the whole world or the only real world. It is possible to interprete any situation adequately without considering it as a whole as well as knowing its parts and the relations of those parts.

4. **The sciences are dependent upon man's sense organs and upon his general intellectual equipment.** The range of man's senses can be increased by the instruments but we cannot provide new senses or change the nature of the organs man has. When we observe, it is always with some "interest". There is a tendency to see what we are trained to see or expect to see. In short, science depends on the human sense organs and the processes of human reason. **They also depend upon assumption and presumptions which are essentially based on faith.**

5. Practice of science is a human activity. Therefore, such concepts as beauty and love, for example, are very real to scientists, as they are to all human beings. But strictly scientific interpretations and understandings of such concepts are impossible within the limits of science.

6. The existence of the presuppositions of science which cannot be verified directly and definitely sets further limits upon science.

SUMMARY

The origin of science is in the common sense method and the existing special sciences have grown out of practical concerns. This led to treat science as trained and organized common sense. But what kind of organisation and classification make a science is not clear by the above definition of science. Hence the distinction between common sense and science must be made.

The common sense knowledge lacks good reason in support of its explanation. It is based on superficial characteristics. They are made without critical thinking and without relevance to facts. Although common sense judgements are apparently accurate, their reasons are wrong. Common sense is usually the product of tradition and hence

there is seldom awareness of the limits within which its beliefs are valued or its practices are successful. It is guided by the practical considerations or values. The common sense is expressed in vague language and hence it is not specific. In spite of all these characteristics. there is an element of science in it. It attempts at understanding, prediction and control of nature. But the dominance of the belief in magic and religion could not pave the way for making it scientific for many centuries.

Sciences are organized bodies of knowledge and classification of their materials is indispensable task. Sciences give explanations which are at once systematic and controllable by factual evidence. The organization and classification of knowledge in sciences is based on explanatory principles. They introduce requirements into ordinary conceptions. Scientific statements make use of highly abstracted concepts. The basic elements of science are understanding, prediction and control.

The word science is derived from Latin word *scientia* which means knowledge. In past, science was defined as a systematic body of knowledge. But this is a very broad definition. Several attempts at the definition of science were made by the scientists and philosophers; but it is very difficult to define the word science because of its dynamic nature. In modern sense the word science is restricted to the body of systematically organised factual knowledge which is obtained by the use of scientific method.

The word science was inadequately defined in the past. The growth of science in the modern times has made it more difficult to define. The nature of science, in general, can be stated as below. The fundamental character of science is that it is a method of approach to the entire world. It is analytic. It enables the scientist to show the relationship between a theory and facts. The practical and theoretical aspects of science are inseparable. The division of science into various branches is conventional. Science may have practical value, but it has purely disinterested desire for knowledge. It is never-ending search for judgments which requires the assent of experts. Self-perpetuation and self-improvement are the goals of science.

Arrangement of the facts in accordance with some definite plan is called an order. There are mainly four types of order. They indicate the four successive stages of the scientific development. They are: (1) The classificatory order; (2) the causal order; (3) Mathematically expressed uniformities; and (4) theories. Classification is done at the beginning of scientfic activity. It represents a low level of order. It is an essential stage in the development of science. The causal order is hardly used in the physical sciences. At one time it was supposed to be equal to scientific explanation. The laws in advanced sciences have to be expressed mathematically, because there is economy in doing so mathematics is often used as a tool in modern sciences. On the basis of a theory many generalisations can be deduced The notion of system lies at the basis of all sciences. To increase the extent and accuracy of the

information collected, a system is constructed. System takes into accounts only that which is capable of proof. The system building in science is a continuous activity. A general system introduces higher type of order.

Scientific knowledge is organised factual knowledge arrived at by the use of scientific methods and techniques. It is objective, verifiable universal. In advance sciences it is expressed in terms and concepts of mathematics. Scientific knowledge cannot be absolutely certain. It is probable. It is self-corrective and hence progressive. Common sense is non-scientific. Either subject-matter, method or both of them should be considered for distinguishing scientific from non-scientific knowledge. Non-scientific inquiry is concerned with more immediate and practical problems.

Magic is a fraudulent art which pretends to an occult control of nature or of spirits. There is a superficial resemblance between magic and science viz., the belief that there are connections in nature or everything is caused in nature. But in magic coincidences are considered as necessary connections. Both discover the mysteries of nature. The aim of magic is to control the nature, the aim of science is primarily the theoretical knowledge.

Religion implies devotion and an object of worship. Science gives importance to disinterested knowledge. Religion stresses personal adjustment and commitment and it treats its convictions as fundamentally true. Science is a continuous process of inquiry and its generalizations are probable.

Philosophy is an attempt to understand the world, its meaning and its value. Its field is broad and inclusive that until the 19h century science was a part of philosophy. Philosophy seeks to unify the results of the sciences and insights of moral philosophy, aesthetics and religion. Philosophy and science have much in common. They grow out of the reflective and inquiring attitude and both are motivated by an impartial love of truth. But sciences deal with special or restricted fields and interprete them in mathematical terms and if possible control them mechanically. The goals of science are description, prediction, experimentation and control. Scientist and philosophers engage in philosophy of science which is one of the few remaining grounds on which they meet.

Science is intimately linked with modern technology. Two are indivisible and technology is a foundation of contemporary society. The activities of scientists are to explain the natural and human world, those of technology are to use these explanations and manipulate this world. There is continuity between these activities. Technology is a systematic knowledge and action, usually of industrial processes but applicable to any recurrent activity. Science deals with man's understanding of the real world about him, the inherent properties of space, matter, energy and their interaction.

The word science is used in two different senses. Broadly, it means a body of ordered knowledge following a method. In its restricted sense it means the body of systematically organized factual knowledge obtain-

ed by the use of scientific method. The word discipline is used in wider sense to include both these senses. But to have the connotation of the modern sense of science, the word science is used in a restricted sense. On this basis mathematics, which uses deductive method and does not consider facts is not a science, it is a discipline. Logic and mathematics are the formal disciplines. Traditionally they were treated as formal sciences because the word science was used in its broad sense. The word discipline is to be used only for our convenience and to ditinguish it from the modern sense of the term science.

Science and formal disciplines differ in using methods, in the subject matter and in the certainty of the conclusion.

Empirical sciences are divided into the natural sciences and the social sciences. The natural sciences consider the structure and properties of matter, whereas the social sciences study the structure and properties of human groups. They may overlap each other. The words 'social' and 'natural' are not mutually exclusive. But the social sciences deal with volitional conduct and judgement of values while the natural sciences deal with causal relations. The natural sciences are exact, but the social sciences are not.

The distinction between pure and applied science is somewhat arbitrary, and difficult. Pure sciences aim at satisfying the needs of the mind, it appeals to the disinterested curiosity of mankind. Applied sciences aim at controlling the events.

There is no agreement over the limitation of science. A few of such limitation are: (1) Science can discover only that which is discoverable by the techniques available at a particular time. (2) No scientific classification includes everything in the subject being classified. (3) Science follows analysis and analysis of an object into the simple units are not more real than the whole object. (4) Sciences are one dependent upon man's sense organs and upon his general intellectual equipment. They also depend upon presuppositions based on faith. (5) Concepts of beauty and love do not come within the limits of science. (6) Presuppositions of science, cannot be verified directly and definitely.

EXERCISES

1. Describe briefly the origin and growth of science.

2. In what respects is science different from (i) Common sense, (ii) Religion, (iii) Magic, (iv) Philosophy, (v) Technology.

3. It is possible to define the word 'science'? Give reasons.

4. Examine the following attempts at the definition: (i) Science is a body of systematic knowledge. (ii) Science is a revolution against superstition and prejudice. (iii) Science is an instrument which is used for the control of nature.

5. "Science by its very nature is analytic and abstract". Explain.

6. Can science be viewed as 'organized common sense'? Give reasons for your answer.

7. Distinguish between empirical sciences and formal disciplines.

8. State the nature of the natural sciences and the social sciences and distinguish between them.

9. "What is Social is also natural" Explain.

10. Distinguish between pure and applied sciences.

11. Distinguish between scientific and non-scientific knowledge.

12. State the characteristics of scientific knowledge.

13. State the limitations of science.

14. Explain the terms order and system.

Chapter Two

PRESUPPOSITIONS OF SCIENCE

What is presupposition? — Nature (Physical realm) is real — Principle of objectivity — Principle of empiricism — Nature is orderly — Principle of parsimony or simplicity — Uniformity of nature — Principle of causality.

WHAT IS PRESUPPOSITION?

We must accept certain things as true before we do our any work or activity. Some facts are quite obvious. We are not even aware that we are presupposing or assuming something before carrying out our activities. For example, we must accept that this world is real before explaining the natural phenomena. In this respect a scientist is not different from a layman. He must justify his activities. A scientist must assume or presuppose some basic things without which he cannot carry out his activities. For example, he must accept that the world is real and that there is order in it. Otherwise, he cannot claim to be a scientist. In other words, science itself rests upon a series of presuppositions. These presuppositions are indispensable, they are fundamentally unproved and unprovable. Science has to presuppose certain ideas or facts. For example, nobody should go against the fundamental laws of thought. There are three laws of thought. They are (1) The law of identity, (2) The law of non-contradiction, and (3) The law of the excluded middle. The law of identity states that if anything is A, it is A. The law of non-contradiction states that nothing can be both A and not A. The law of the excluded middle states that anything must be either A or not A. These are the logical principles of thought and they are involved in every proof. Every proof depends upon them, whether we know them explicitly or not, or whether we have faith in them or not.

The presuppositions are basic and cannot be verified directly and definitely. Presupposition is a piece of information, a principle or an attitude that a person accepts as correct without personally proving it. On the basis of presupposition he carries out his activities. According to Schilling, a physicist, "presuppositions are inevitable ... so the issue is whether they are legitimate, significant and fruitful". This issue can be solved by considering the basic presuppositions in detail. The basic presuppositions are: (1) Nature is real. (2) Nature is orderly. (3) Principle of Parsimony or simplicity. (4) Principles of uniformity of Nature and (5) Principle of causality.

1. NATURE (PHYSICAL REALM) IS REAL

If the world were not real, the scientist would not have been able to test his hypotheses by appealing to facts. When a scientists appeals to the facts in nature, he must have faith in their existence. It is important to note that most of the facts can be repeated and controlled by the scientists. It shows that they must really exist in nature. So the science presupposes that nature is real. From a particular standpoint, the world may be an illusion to a philosopher, but it cannot be an illusion to a scientist because his methods of finding out the truth is essentially different from that of philosophy. So there cannot be any disagreement among the scientists about the reality of this world or nature. The world is real and its reality is objective and hence open to all for verification. The scientist follows the method of observation and he demonstrates how a scientific observation can lead to the understanding of the real world which is not necessarily known to a common man. But to make the people believe in this presupposition, the scientist lays down certain conditions of observation and the use of certain methods and techniques. In short, his observation is based on the principle of objectivity and empiricism.

The Principle of Objectivity: This principle states that the investigator must be impartial as regards the data before him. The aim of this principle is to eliminate all subjective and personal elements. This principle implies that the facts must be such that they can be experienced in exactly the same way by all normal people.

The Principle of Empiricism: This principle assumes that the test of truth consists in appealing to the experienced facts. Knowing is the result of observation, experience and experiment This principle assumes that the sense impressions of the investigator or the scientist are reliable. Science assets that the physical world exists. The scientist believes that he can co-ordinate the facts of sensible experience. He assumes that the physical world can be known through the use of various sense organs. aided in most cases by scientific devices such as telescopes. microscopes. etc. This postulate is accepted because. without this postulate. science could not exist. This postulate is opposed to authority or intuition. This principle also implies that we cannot know only through reason. To rely on authority or intuition is not to use the scientific method. We have. therefore. to observe this world scientifically through our senses aided by scientific devices.

According to Polanyi who is both a scientist and a philosopher. "scientific discoveries are made in the search of reality —of a reality that is there, whether we know it or not. The search is of our own making. but reality is not . . . For the scientist's quest presupposes the existence of an external reality". Einstein stated the same point bluntly: "The belief in an external world independent of the perceiving subject is the basis of all the natural sciences." The only disagreement among the scientists as well as philosophers is as to the question of just how much and what is assumed to be real. As a bare minimum, the reality of the physical realm must include the fundamental particles and the natural laws.

2. NATURE IS ORDERLY

The principle is very broad and significant. It has arised out of the growth of sciences. It has become an article of faith for scientist. The belief in the principle of order in nature enables the scientist to connect the different facts and to discover laws. The laws state the relationship between the different facts. For whatever occurs in nature there must be some order of occurrence and the scientist engages himself in finding out that order by framing a hypothesis and verifying it with the facts. In the first chapter we had discussed the four types of order. These types of order help the scientist to make advance-

ment in science and to explain the phenomena. But order cannot be seen at once. It is to be discovered and unless there is faith in the principle of orderliness in nature, it cannot be discovered.

Moreover, order that is discovered by a scientist is such that it seems to give better sense of reality than what we know about reality. In short, the system of nature is intelligible to different sciences and each science explains the different orders in nature. According to Bronowski, "The notion of order cannot be defined on any ground except its success. It cannot be put into a science in advance at all. Order is the selection of one set of appearances, rather than another because it gives a better sense of the reality behind the appearances. Science is an orderly language for describing some events and predicting others like them. The order is a selection of appearances and imposes an interpretation."

3. THE PRINCIPLE OF PARSIMONY OR SIMPLICITY

This principle cautions against complicated explanation. The principle suggests that if other things are equal, a person should take the simplest explanation as the most valid one. It is sometimes called 'Occam's Razor', since William Occam, a fourteenth century English philosopher, said that "entities should not be multiplied beyond necessity". Sir William Hamilton expresses Occam's canon in more complete and adequate form. "No causes are to be assumed than are necessary to account for the phenomena." This canon expresses no dogma but a fundamental principle of economy of thought. In other words, a theory must be simple. Let us see what does the word simple mean.

The word simple is often used in our day-to-day conversation to mean that something is easy for understanding. It may also mean that what is unknown and unfamiliar has made known and familiar by suitable illustrations or explanations. The word simplicity is not to be taken in this sense when we think of it as a presupposition of a science. There are many interpretations about the use of the word simplicity as a presupposition. There is neither agreement over its meaning nor there is any agreement over its justification. The word simpli-

city if applied to theories may mean a theory should have small number of basic concepts or there must be economy or parsimony in assuming. It may also mean a dynamic character i.e. capacity of theory to predict the future. Such theories are comprehensive. Karl Popper states that if a theory is comprehensive, it has a lot of empirical content and hence it is liable to be false. So in what sense should we use the world simple is a problem. The following example may clarify a sense in which the word simplicity can be used. Copernicus' theory could explain motion of our planetary system, but Newton's theory could explain all motions of celestial bodies as well. It was therefore, simpler. Newton's ad hoc supposition of the concept of force makes it less simpler than Einstein's theory of relativity because a simple theory should have no ad hoc supposition. But what is the justification for accepting the principle of simplicity? There is no agreement about the justification of the word simplicity. It may be either justified on the ground that it requires no justification. The goal of science is to explain and to explain something is supposed to simplify phenomenon. But the concept of explanation is quite different from that of simplicity. Moreover, the rule of simplicity cannot be assumed about the nature of the world. It cannot be said that simple theory represents the system of nature more accurately. In other words, no attempts at the justification of the principle of simplicity is tenable.

4. UNIFORMITY OF NATURE

A scientist may give first place to the assumption that nature is uniform. It is usual to regard that nature is uniform in the sense that tomorrow will be like to-day, future will resemble the past, unknown will resemble the known etc. It implies that past experience is a reliable guide to the future So we try to put bounds on nature so that it is to obey the same laws tomorrow as it obeyed to-day. In the following examples such as lightning is followed by thunder, day is followed by night, water boils at 100 degrees centigrade etc. we find that there is regularity in nature. Due to such regularity, prediction is possible in science. In other words, there are parallel cases in nature. But such contention is untenable because one cannot generalize about the course of nature. As a presupposition it

must clarify the extent of uniformity otherwise it will be meaningless. Scientists never assume a general uniformity. He only assumes that there is Order in Nature and it is intelligible.

5. THE PRINCIPLE OF CAUSALITY

It is the belief that every event has a cause and that, in identical situations, the same cause always produces the same effect. What is assumed in science is that event A will be observed to follow from event B. The causal relationship is assumed to occur in time and space. The scientist also assumes that there are discoverable uniformities in Nature. What happens, happens in accordance with laws and these laws are such that we can discover them.

The concept of cause has a limited application. For understanding of natural phenomena a cause is defined as a set of necessary and sufficient conditions for the occurrence of an event. A necessary condition is one in the absence of which the effect would not occur. The sufficient condition is one in the presence of which the effect must occur. Cause is inseparable from the effect. In its practical application, notion of cause may mean either a set of necessary conditions or a set of sufficient conditions. If the aim is to prevent an effect, a set of necessary conditions are considered and if the aim is to produce a certain effect, a set of sufficient conditions are considered. As science progresses, it takes into account the nature of structural properties or functional dependencies. In such cases the notion of causation cannot be used for explanation. The exact sciences have therefore dropped the notion of causation. The concept of causation received its biggest jolt on account of the quantum theory and the theory of relativity. According to quantum theory, energy always appears in quantum packets of definite sizes. As this theory states the continuous operation in an absolute time, this theory goes against the concept of causality. According to Eddington, "There is no strict causal behaviour anywhere; it is impossible to trap modern physics into predicting anything with perfect determinism because it deals with probabilities from the outset." When we use the principle of causality as a presupposition we use it in a loose sense. But it cannot be regarded as the presupposition of science because physical sciences do not seek to discover causes of phenomena.

We must keep in mind the principle of uncertainty or indeterminacy stated by Heisenberg. We must realize that the principles of sciences are undergoing significant revision. For example, electrons change position in an unpredictable manner. So the principle of causality cannot be regarded as the presupposition of science.

The practical significance of presupposition in the practice of science may be described by reference to what Kuhn designates 'scientific paradigims.' The term paradigim refers to the total complex of a science or of some area within that science It includes the concepts, which are generally accepted as true within that science, along with its languages, theories and methodologies. It determines to a considerable extent the way in which a scientist sees his data, the experiments he conducts and the observations that he interprets.

SUMMARY

Presupposition is a piece of information, a princnple or an attitude that a person accepts as correct without personally proving it. They are inevitable for both a layman and a scientist. The basic presuppositions are: (1) Nature is real, (2) Nature is orderly, (3) Principle of parsimony or simplicity, (4) Principle of uniformity of nature. (5) Principle of causality.

The scientist must believe in the reality of the world or nature. He appeals to facts because he believes that the reality is objective. As he follows the method of observation and experimentation he must have faith in the existence of the physical realm. The faith in it is the basis of all the natural sciences. As a bare minimum, the reality of the physical realm must include the fundamental particles and the natural laws.

Scientist believes in the orderlines of the nature. It has become an article of faith for scientist. The belief in the order helps the scientist to show connection between the different facts. On this belief he frames a hypothesis and verifies if with the facts. The order is to be discovered by the scientists. It gives better sense of reality.

The principle of parsimony or simplicity suggests that entities should not be multiplied beyond necessity. This explanation is called Occam's Razor. It means no causes are to be assumed than are necessary to account for the phenomena. It expresses the principle of economy of thought. The meaning of the word simple is quite different from its ordinary sense. It does not mean familarily, or making something easy for understanding. It has a variety of meanings. Neither its meaning nor its justification is acceptable to all the scientists.

The principle of uniformity of nature is assumed by the common man because they find regularity of events and parallel cases in nature. But one cannot generalize about the course of nature. Scientist never assumes a general uniformity. He only assumes that there is order in nature and it is intelligible.

The principle of causality asserts that every event has a cause and in identical situations, the same cause always produces the same effect. But the concept of cause has limited application of understanding of natural phenomena. A cause is defined as a necessary and sufficient conditions for the occurrence of an event. As science progresses, it takes into account the nature of structural properties or functional dependencies. In such cases nature of causation cannot be used for explanation. The exact sciences have dropped the notion of causation. Physical sciences do not seek to discover causes of phenomena. So it cannot be regarded as presupposition of science.

EXERCISES

1. What is meant by presupposition?
2. What is the practical significance of presuppositions?
3. Explain the following presuppositions. (i) Nature is real. (ii) Nature is orderly. (iii) Principle of simplicity. (iv) Principle of uniformity of nature. (v) Principle of causality.
4. State and explain whether physical sciences presuppose the principle of causality.
5. Can you justify the principle of simplicity?
6. Is unifomity of nature same as the order of nature?

Chapter Three

SCIENTIFIC METHOD

Scientific method — The hypothetico-deductive method — Scientific method and evidence — Attitude of scientist.

SCIENTIFIC METHOD

The procedures by which science generates the body of knowledge are referred to as tools, techniques and methods. By a scientific tool we mean physical or conceptual instrument used in scientific inquiry, e.g. mathematical symbols, computers, microphones, telescopes, etc. By a scientific technique we mean a way of accomplishing a scientific objective or a scientific course of action. By a scientific method we mean the way techniques are selected in science. Strictly speaking, the term "method" means "following a way". It refers to the specific steps which must be taken to achieve a given end. The term scientific method, if applied to scientific investigation in general, can only refer to the lowest common denominator of a range of methods devised to cope with problems as classifying stars and curing diseases.

Scientific method aims at discovering what the facts truly are. They cannot be discovered without reflection, because sensory experiences are deceptive. Sensory experience sets the problem for knowledge. We should, therefore, inquire into the felt problem. We will have to select the facts for scientific investigation. The selection of the fact determines the subject-matter of our inquiry. It is idle to collect facts unless there is a problem upon which they are supposed to bear. After collecting the facts we may suggest a hypothesis (i.e. any provisional explanation) to clarify the facts under investigation. Hypotheses are suggested to an inquirer by something in the subject-matter

under investigation and by the inquirer's previous knowledge of other subject-matters. No rules can be given for obtaining fruitful hypotheses. Hypotheses are required at every stage of an inquiry. Hypotheses can be regarded as suggestions of possible connections between actual facts or imagined ones. The question of truth of hypotheses need not, therefore, always be raised. There may be any number of hypotheses. The number of hypotheses has no limit, because their occurrence depends on imagination. It is the task of an inquirer to determine which of the hypotheses is in best agreement with the facts. No hypothesis which states a general proposition can be demonstrated as absolutely true, because all inquiries dealing with matters of fact employ probable inference. Science demands and looks for logically adequate grounds for hypotheses. Science is ready to abandon a hypothesis or a theory when the facts so demand. In other words, verification of hypothesis is done. Even if a hypothesis is abandoned on verification, it does not mean that a hypothesis is useless. It helps science to progressively realize its ideal. By virtue of its method, the enterprise of science is a self-corrective process. It claims no infallibility, but relies upon the methods of developing and testing hypotheses.

It is increasingly recognized that there is a unity of method in all generalising or theoretical sciences. It is sometimes called the hypothetico-deductive method. It is important to realise that in science we are always concerned with explanations, predictions and tests and that the method of testing hypotheses is always the same. From the hypothesis to be tested, we confront the prognosis wherever possible, with the results of experimental or other observation. Agreement with them is taken as corroboration of the hypothesis, though not final proof. Clear disagreement is considered as refutation or falsification.

THE HYPOTHETICO-DEDUCTIVE METHOD

The general features of "the Hypothetico Deductive Method" can be stated briefly as followes :

1. The hypothetico-deductive method, as the very name suggests, is not an absolutely inductive method. It makes use of both inductive and deductive reasoning.

2. This method is used extensively in scientific investigation. Experience shows that this method can be profitably used in everyday life to solve the ordinary non-scientific problems also.

Stages in the Hypothetico-Deductive Method

This method has four main stages:

1. **Feeling of a problem:** A scientist's observation reveals some puzzling facts. These facts pose a problem.

2. **Formulation of a hypothesis:** A tentative supposition is made to explain the facts which call for an explanation. The supposition is made on insufficient evidence. We must remember that, at this stage, some past experience is necessary to pick up the significant aspects of the observed facts. Without previous knowledge, the investigation becomes difficult, if not impossible. The present circumstances also force the scientist to think of certain possible solutions. Both past experience and present experience combine to influence the selection and rejection of some solutions even before they are actually tried out.

3. **Deductive development of hypothesis:** At this stage, a scientist makes use of deductive reasoning. He constructs a deductive argument by supposing that the hypothesis is true. He uses the hypothesis as a premise, and draws a conclusion from it. In other words, he deducts implications from the hypothesis.

4. **Verification of hypothesis:** This consists in finding whether the conclusion drawn at the third stage really takes place. In other words, verification consists in finding whether the hypothesis agrees with facts. If the hypothesis stands the test of verification, it is accepted as an explanation of the problem. But if the hypothesis does not stand the test of verification, the scientist is thrown back upon the search for further solutions. A hypothesis thus stands somewhere at the midpoint of research; from here one can look back to the problem and also look forward to data. If the hypothesis holds good under all circumstances, it may be elevated to the category of a theory, or even, if sufficiently profound, a law.

The study of scientific method is frequently referred to as methodology. The objective of methodology is the improvement of the procedures and criteria employed in the conduct of scien-

tific research. The logical analysis of the method whereby generalizations and theories are obtained constitutes the theory of scientific method. It involves the following steps. (a) Making observations as accurate, definite, relevant and verifiable as possible; (b) recording these observations intelligibly; (c) classifying them according to the subject being studied; (d) extracting from them by induction, general statements which assert regularities concerning the whole class of things; (e) deducing other general statements from these general statements; (f) verifying these statements by further observation; and (g) propounding theories or hypotheses which connect and account for the largest possible number of these facts. The whole process may lead to the statements of scientific law. It is the task of the logic of scientific discovery to give a logical analysis of this procedure, that is, to analyse the method of empirical science. The following chapters will clarify this entire procedure in detail.

Scientific Method and Evidence

As we know, a scientist makes generalizations on the basis of observed facts. First he has to collect information or data through observation. On the basis of these observed facts he makes generalization. If the generalizations in the form of hypotheses agree with the facts, they are said to be established or confirmed. Thus, agreement with facts of experience is the condition of generalizations. These facts are regarded as evidence. Of course, evidence is of two kinds. They are: direct evidence and indirect evidence. In positive sciences like chemistry, physics, biology, botany, the scientist is interested in direct evidence. For instance, Newton's law of gravitation was confirmed by direct evidence.

Indirect evidence consists in deducing the consequences from the generalization which cannot be directly confirmed and these consequences are then confirmed by appealing to the facts of experience. When the consequences thus confirm the generalizations, the generalizations are said to be confirmed by indirect evidence. In other words, sometimes generalizations form themselves into a system in which the reliability of one generalization depends upon a higher or wider generalization.

It is clear that the facts which confirm higher generalization in a system also confirm the generalization under consideration. We know that Galileo's law of freely falling bodies is more general than Newton's law if gravitation, and Einstein's theory of relativity is more general than the law of freely falling bodies. So Einstein's theory of relativity includes in its scope gravitation, electrical energy, and mechanical energy. Here, the evidence for the theory of relativity is not only those specific consequences which confirmed it, but also includes all the evidence that confirm gravitation and mechanical and electrical energy.

Attitude of Scientist

Science is a systematic or organized body of knowledge. This systematic body of knowledge demands that the scientist should be objective. He should not be dogmatic. He should not accept anything blindly. He always has to see the supporting evidence. The conclusions he arrives at should be based upon facts and not upon his likes and dislikes. Thus he should be guided by evidence and not by any other thing. Occupational, political, social, racial, national considerations should not be allowed to influence the outlook of a scientist.

A scientist should always remember that there is no such thing as a last word in science. He should be open-minded in the sense that he should be prepared to modify his theory if the facts go contrary to the theory. In the history of science, we come across a number of cases where there was no sufficient evidence in support of the hypotheses of the scientists. When those scientists found that there was no evidence to back up hypotheses, they rejected or modified those hypotheses. Thus, scientists is not rigid in his approach. He is open for correction.

A scientist takes a very rational outlook. He uses 'doubt' as his weapon. Whenever an event takes place he asks 'why the event has taken place?' Then he formulates a tentative hypothesis on the basis of available evidence. His hypothesis is not a mere guess-work. It has its roots in facts. Thus a scientist begins with doubt and therefore ends with certainty. It is well known fact 'the people who start with certainty, end with doubt, but the people who start with doubt end with certainty.'

Let us see some investigations from the history of science. We can identify the scientific method used in them.

(1) Eijkman thought that beri-beri was caused by a bacillus. He had, however, noticed that the hens in the courtyard of the prison where he worked acted as the human prisoners who had beri-beri. This phenomenon made him think: could the hens' illness and that of the prisoners have the same cause? Hens and the prisoners had one thing in common—the food the prisoners threw out of their windows into the yard. Eijkman enquired with other prison authorities also. He found that some had many cases of beri-beri and others had quite a few cases. He began to think about the diet. Was it the same? No. He found that the diet in different prisons differed greatly. Then he began to think: what else could be the cause? He found that the prisons with much beri-beri, the common factor was 'polished rice'. In those prisons with a few cases of beri-beri, the prisiners were given unhusked rice, which is cheaper. Eijkman thus concluded that the husk of rice contains something the lack of which causes beri-beri.

(2) Astronomers had calculated the orbit of the planet uranus. But in 1820, it was noticed that uranus deviated from its orbit. What could be the cause of this deviation? Why should the planet deviate? Astronomers started thinking about this problem. As an answer or a solution to the problem, astronomers advanced a tentative hypothesis. They advanced the hypothesis that there is a planet beyond uranus which is attracting uranus to itself. On the basis of the law of gravitation, the size, and the position of the unknown planet was calculated. In the end, the astronomers discovered this planet and it was named 'Neptune'.

SUMMARY

The procedures by which sciences generate the body of knowledge are called tools, techniques and methods. The term 'method' means following a way'. It refers to a specific step which must be taken to achieve a given end. Scientific method aims at discovering the facts, we enquire into the problems. In order to solve a problem, we advance hypotheses. The method used here is referred to as 'The Hypothetico-Deductives Method. The hypothetico-deductive method has four main stages. They are: (1) Feeling of a problem; (2) Formulation of a hypothesis: (3) Deductive development of a hypothesis; and (4) Verification of hypothesis.

While making generalizations, a scientist takes into consideration the observed facts. If the generalizations in the form of hypotheses agree with the facts of experience, the generalizations are said to be confirmed or established. The facts constitute the evidence. Evidence is of two kinds: Direct and indirect.

While making generalizations and establishing theories, a scientist takes a specific attitude. His attitude is different. A scientist is open-minded. He is open for correction. If he finds that the hypothesis he has advanced lacks the sufficient evidence in its support, he is prepared to modify or even to reject his hypothesis. He takes a very rational outlook. Scientist uses doubt as his weapon. He starts with doubt and therefore ends with certainty.

EXERCISES

1. What is a scientific method?
2. State the various steps involved in scientific method.
3. What is the place of evidence in scientific method?
4. Bring out the features of a scientific attitude.
5. Explain the nature of hypothetico-deductive method.

Chapter Four

SIMPLE ENUMERATION, ANALOGY AND MODELS

Inductive generalization — Simple enumeration — Characteristics of simple enumeration — Analogy: positive, negative and neutral analogy — Conditions of sound analogy — Role of analogy in science — What is a model — Scientific explanation and analogy — Purposes of models — The source and the subject of models — Models and hypothesis — Models in theoretical science.

INDUCTIVE GENERALIZATION

In our everyday life we often make general statements. A scientist also makes general statements. These general statements are called generalizations. Generalizations are based upon observation. We collect evidence in support of generalization through observation. But here our observation is not complete. We observe only some instances of a class and not all the instances of a class. Now, we find that the observed instances have a certain similarity. They possess a particular characteristic in common. On the basis of this observation, we generalize. We believe that what is true of the observed instances, will be true of the unobserved instance. Since we have an uniform experience, we expect that we shall have it even in the future. We are quite conscious of the fact that the observed instances do not constitute all the members of a class concerned. But we have a tendency to generalize. A generalization is a statement whose scope is wider than the evidence for it. Inductive leap or passage from known or observed to unknown or unobserved is the essence of inductive generalization. Thus, our generalizations "All swans are white". "All metals conduct electricity" etc. are inductive generalizations. But inductive generalizations are of two kinds. (1) Generalizations established by scientific induction; (2) Generalizations estab-

lished by simple enumeration and analogy. The generalization 'All metals conduct electricity' is arrived at by the process of scientific induction, while the generalization "All swans are white" is arrived at by the process of simple enumeration. Generalizations established by scientific induction are supported not only by the principle of uniformity of nature, but also by the principle of causation. Generalizations established by simple enumeration lack this support.

SIMPLE ENUMERATION

Simple enumeration consists in arguing that what is true of several instances of a class is true of all the instances of a class. According to Mill, "Simple enumeration consists in ascribing the character of general truths to all propositions which are true in every instance that we happen to know of." Thus the basis of simple enumeration is mere uncontradicted or uniform experience. For example, we observe some rose plants and find that every rose plant which we have observed possesses thorns. On the basis of this uniform but insufficient evidence, we make a generalization, "All rose plants possess thorns." Similarly, we observe some crows. They are black. So far our experience about crows is concerned, we have never come across a crow of any other colour except black. On the basis of this uniform or uncontradicted experience, we generalize "All crows are black."

The form of this kind of reasoning is:

All observed Ps are Q.

(No observed P is non-Q)

∴ All Ps are Q.

Simple enumeration has the following characteristics:

(1) **Generalization is established on the basis of uniform or uncontradicted experience.** Here the belief is that the nature is uniform. This belief is strengthened by the absence of any contradictory instance. Thus, as we have seen above, we observe some crows. They are black. We do not come across any contradictory instance, i.e., we do not come across a crow of any other colour except black. On the basis of this uniform or uncontradicted experience, we expect to find all crows black.

Hence we generalize "All crows are black". Thus the generalization is based upon the belief that the nature is uniform, and that there are no contradictory instances and even if there were contradictory instances, we would have come across them in the process of observation.

(2) **Generalization is established on the basis of the observation of some instances and not all the instances of a class.** Only a part of the class is observed, but our generalization covers the whole class. Thus in the above example, we observe only some crows and not all crows. But we extend the property 'black colour' to the whole class of crows. We generalize 'All crows are black'. This process is known as inductive leap. We pass from the observed to the unobserved or from the known to the unknown instances. Of course, this inductive leap or the passage from the observed to the unobserved is based upon our belief that the nature is unifom. Without this belief no knowledge would be possible.

(3) **Generalizations are not based upon the scientific analysis of properties of the instances observed.** The generalization does not attempt to see why certain properties go together, e.g. All swans are white". Here no attempt is made to find out why the property 'whiteness' goes with swans. Moreover, the distinction between meaningful relationship and coincidence is not made. This distinction is absolutely necessary in the scientific method.

(4) **Simple enumeration gives us conclusions which are only probable and not certain.** In simple enumeration confirming instances are few. i.e. we observe only some instances of a class and not all the instances of a class. On the basis of the similarity in observed instances, we argue that what is true of the observed instances will be true also of the unobserved instances. We believe that the nature is uniform. But the expectation is one thing and facts the other. We cannot be confident that the next unobserved instance will have the same property as the observed instances. The property which we have found in many observed instances may be a mere chance or coincidence and that we may come across a contradictory instance. If we come across such a contradictory instance in future, our generalization would be overthrown. The generaliza-

tions "All roses possess thorns" and "All crows are black" will be overthrown, if we come across a single rose which does not possess thorns or a single crow which is not black. These generalizations will have to be discarded. Thus, the generalizations established by simple enumeration are probable and not certain. Therefore, Mill and Bacon considered simple enumeration to be unreliable. According to Bacon, 'induction which proceeds by merely citing the instances is a childish affair and being without any principle of inference, it may be overthrown by a contradictory instance."

(5) **Though the generalizations established by simple enumeration are probable, they differ in their degree of probability.** We have uniform experience in respect of instances that resemble one another. The value of the generalizations established by simple enunciation depends on whether these resemblances are important or unimportant. When the resemblances are important, the conclusion will have greater probability Thus the generalization, "All swans are white" is more probable than the generalization, "All brown-eyed people are cunning", because brown eyed people do not have much in common. They resemble one another only in the characteristic, namely the colour of eyes. This characteristic cannot be considered as important for inferring cunningness. On the other hand, swans have many characteristics in common and some of these characteristics are important. Thus we say that the greater the number of positive instances, the greater would be the probability of the conclusion. In this respect, the two processes, simple enumeration and analogy come closer.

The Role of Simple Enumeration in Scientific Investigation

Simple enumeration is very useful in our daily life. Our time and energy are limited. We cannot observe each and every instance of a class. Therefore, after observing a large number of a class, we generalize and say that what is true of the observed instances of a class will be true of all the instances. This saves our time and energy.

Simple enumeration is useful in scientific investigation also. Simple enumeration by itself does not have a place in

scientific investigation. But science depends very much upon simple enumeration. Generalizations arrived at by simple enumeration suggest scientists the hypothesis. As we know, the aim of scientific inquiry is to establish causal relationship Scientists seeks to explain the facts by discovering and connecting links. Simple enumeration sometimes suggests these connections. As Grumley puts it, "The chief value of the enumerative method lies in its power to suggest causal relation. The condition that two phenomena are always or very frequently connected seems sufficient ground for entertaining the hypothesis that they are causally related." Thus simple enumeration suggests causal relation to scientist. Many times the problems also are suggested to a scientist by simple enumeration. Simple enumeration suggests that there is a kind of uniformity in the observed instances. They go together. This uniformity makes a scientist think as to why certain events go together or why certain things possess certain properties. This leads to the scientific investigation. Thus simple enumeration plays its role in scientific investigation.

Let us take an example and see how simple enumeration provokes scientific thinking.

(1) Christian Eijkman observed several cases where men as well as hens suffered from beri-beri. After studying them carefully, he found that these men as well as hens were fed on un husked rice, i.e. polished rice. Eijkman generalized 'the husk of the rice contains something the lack of which causes beri-beri.'

(2) The discovery of the cause of yellow fever is another example. Finlay observed that in the areas affected by yellow fever epidemic there exist certain mosquito (aedes calopus). On the basis of this observation, he generalized 'yellow fever is caused by aedes calopus.'

ANALOGY

Analogy may be defined as an argument from partial resemblance to further resemblance. It is an inference in which the conclusion is drawn on the basis of observed or known similarities. The structure of an analogical argument is as follows:

A resembles **B** in certain properties, viz., **X, Y** and **Z.**

A possesses another property **P**

B possesses property **P.**

Let us take concrete examples of analogical argument from every day life as well as from science.

(1) Sheela and Sudha resemble one another in height. colour of the skin and intelligence. Sheela knows car-driving. Therefore Sudha also must be knowing car-driving.

(2) Deepak and Sudha come from the same socio-economic background. They belong to the same community. They studied in the same school as well as in the same college. Sudha is well-mannered. Therefore Deepak also must be well-mannered

(3) The astronomers who believed in Galileo's discovery of the four moons of Jupiter argued that: The four moons are smaller than Jupiter and they revolve round it. All other planets are smaller than the sun. Therefore, all the planets in the solar system must be revolving round the sun.

(4) Chlorine and iodine have many resemblances in common. Corresponding to almost every compound containing iodine, there is a compound containing chlorine. A scientist has recently discovered a new compound containing iodine. Therefore, it is argued that a new compound containing chlorine will be discovered.

From the above examples, it is quite clear that an argument from analogy consists of three stages.

(1) Two things resemble each other in certain respects.

(2) One of the things possesses a certain additional quality.

(3) On the basis of the first two stages as the evidence, we arrive at the conclusion that the second thing also possesses the additional quality.

Thus, an analogical argument is based upon our belief that since two instances possess certain characteristics in common, what is further possessed by one is also possessed by another. Therefore, R. Harre defines analogy as "a relationship between two entities, processes, or what you will, which allows inferences to be made about one of the things, usually that about which we know least, on the basis of what we know about

the other." Of course, it would not be correct to describe analogy as an argument from particular to particular. As an inductive argument, analogy relies even on the correspondence between the two sets of characteristics and therefore infers the further, additional characteristics on the basis of the one observed earlier.

Analogy depends upon the characteristics. On the basis of these characteristics, we have three kinds of analogy. They are:

(1) Positive analogy

(2) Negative analogy

(3) Neutral analogy.

Positive Analogy

As R. Harre says, analogy is a relation between two entities or processes such that inferences about one of them can be made on the basis of what we know about the other. Now, between two entities, instances or processes there will be some likenesses, some unlikenesses, and some features which are not known to be either likenesses or unlikenesses. **Likenesses between entities constitute positive analogy.** When two things resemble one another in certain respects, it is reasonable to expect that they will resemble in other respects also. Let us understand the notion of positive analogy with the help of Lowell's analogy about life on Mars. Lowell argued like this: It is known that Earth and Mars resemble one another in being planets, in revolving round the sun, and in possessing water, atmosphere and temperature. Since there are living beings on Earth, there are living beings on Mars.

In this example, the characteristics 'planets, revolve round the sun, possess water, atmosphere and temperature' constitute positive analogy, because these are the likenesses between Earth and Mars. The strength of analogical argument depends very much upon the positive analogy. If the positive analogy constitutes the important characteristics, an analogical argument has a high degree of probability.

Negative Analogy

As we have already seen, between two entities, instances or processes there will be some likenesses, some unlikenesses and

some features which are not known to be either likenesses, or unlikenesses. Now, **the unlikenesses or differences between instances, entities or processes are called negative analogy.** Negative analogy is not as important as the positive analogy. In some cases negative analogy is not known. And even if it is known, we draw the inferences on the basis of positive analogy. We weigh the positive and negative analogy, and as the balance stands, stands the question of validity or invalidity of an analogical argument.

Neutral Analogy

As we have seen already, between two entities, instances or processes, there will be some likenesses, some unlikenesses, and some features which are not known to be either likenesses or unlikenesses. **The features which are not known to be either likenesses or unlikenesses constitute neutral analogy.** In other words, in spite of analysis, a large number of qualities showing likenesses or unlikenesses between two instances remain unknown. These unknown qualities constitute neutral analogy.

In analogical argument we take into consideration the likenesses and unlikenesses. From these likenesses and unlikenesses we infer the unknown likenesses or unknown unlikenesses. In other words, from positive analogy and negative analogy, we infer neutral analogy. R. Harre gives the example of neutral analogy. He says: Suppose we compare a horse with a car. There are certain likenesses in that both are used as means of transport, both cost a certain amount to buy and to maintain. There are unlikenesses in that only in the choice of breeding partners does the hand of man interfere in the production of horses. Horses are organisms, cars are machines. Cars can be repaired by replacing worn-out parts from an external source, but this technique is of limited application for the horse. Suppose we learn that a certain city uses only horse transport, but we know nothing else about their system. We can make certain inferences about the traffic density from what we know about cities which use mechanical transport on the basis of the likenesses between horse and car as means of transport and we can make other inferences about the air pollution based upon what we know of the unlikenesses between them. In this way,

by the use of analogy, we penetrate our area of ignorance about a city whose transport is by horse.

Conditions of Sound Analogy

Analogy is a proper but imperfect form of induction. It is based upon imperfect resemblances. It gives us probable conclusions. Of course, all conclusions arrived at by analogy are not equally probable. The degree of probability will vary according to the nature of the points of resemblance. Some conclusions have a high degree of probability, others have a low degree. Now, let us consider the conditions on which the force of an analogical argument depends.

According to Mill, the probability of an analogical argument depends upon three conditions. They are (1) the extent of known resemblances, (2) the extent of known differences, and (3) the extent of explored region of unknown properties. He pointed out that, where the resemblance is very great, the ascertained difference very small and our knowledge of the subject-matter quite extensive, the argument from analogy has a high degree of probability.

Mill's emphasis here is on the number of points of similarity and difference. But the criteria proposed by Mill do not seem to be acceptable, for two things may resemble one another in many qualities and yet the argument may have no value whatsoever if the resemblances are unimportant properties. For example, two girls resemble one another in sex, age, mother-tongue, religion, socio-economic status. One of them likes the subject "Scientific Method". Can we, therefore, infer on the basis of analogy that the other girl also likes the subject "Scientific Method"? Or can we say that if one is a dancer, the other also is a dancer?

It is quite evident that such inferences cannot be drawn with confidence. The above argument satisfies Mill's conditions and yet it does not possess a high degree of probability. Thus, since Mill lays stress only on the number of points of resemblance and not on the importance of such points, Mill's view has to be rejected. Known similarities and known differences may be either relevant or irrelevant. Force of analogy does not depend upon the irrelevant qualities. Therefore, the force of

analogy must be measured by comparing the number and importance of the points of similarity with the number and importance of the points of difference.

There are three conditions of a sound analogical argument.

(1) **The greater the number and the importance of the known points of resemblance, the greater is the probability of an analogical argument.**

It is necessary that the resemblances should be not only maximum, but should be important also, i.e. they must be relevant. The relevance has a great value in analogy. To take an example: It is known that Earth and Mars resemble one another in being planets, in revolving round the Sun, and in possessing water, atmosphere and temperature. Since there are living beings on Earth, it is argued that Mars is also likely to have living beings In this analogy, the resemblances, atmosphere, water and temperature, are important, i.e. relevant. These are the essential conditions of life.

(2) **The greater the number and importance of the known points of difference, the less the probability of the analogical argument.**

Those qualities in which we know that the observed instances differ are called the known negative analogy. Whenever we compare two things, we are bound to notice the differences of properties among them. But if the differences are numerous and more important than the resemblances, the analogical argument will have a low degree of probability. To take an example: Moon resembles Earth in being solid, being nearly spherical, appearing to contain active volcanoes, receiving heat and light from the Sun, and revolving on its axis. There are living beings on Earth. Therefore, it is argued, on the basis of analogy that there are living beings on the Moon. In this analogy, from the point of justifying the conclusion, i.e. life on Moon, the resemblances are not important. On the contrary, the differences between Earth and Moon are more important. We know that the Earth has atmosphere, but the Moon does not have atmosphere. Air is essential for life. Therefore, the argument is weak or it has low degree of probability.

(3) The generalization should not extend too much.

It is true that, where the similarities are more important and the differences are less important, the argument from analogy is sound. But this does not justify inferring more than what is supported by the evidence. The conclusion should not assert something unjustifiably more than what is justified by the evidence. To take an example: As we saw. in the first condition of analogy, Earth and Mars resemble one another in so many characteristics. These resemblances justify the inference that there may be living beings on Mars. This argument is good But if we argue that since there are human beings on Earth, there are human beings on Mars, the argument will unsound, for the resemblances do not justify the conclusion. This will amount to going too far in the analogical argument.

Role of Analogy in Science

Analogy is of great importance in Science.

(1) Firstly, analogy suggests a hypothesis. As we know, all scientific investigations are guided by hypothesis. Since analogy suggests these hypothesis, we can understand how important is an analogy in science. We can see how analogy suggests hypothesis in science, with the help of some examples from the history of science.

(a) The analogy of a falling apple and the idea of a falling moon suggested to Newton the law of gravitation.

(b) The analogy between competition in the industrial world and the struggle for survival among the biological species suggested to Darwin his theory of Natural Selection.

(c) The analogy of water waves and sound waves suggested the wave theory of light.

(d) Rutherford propounded a theory of transmutation of elements. He argued that the atom was like a solar system. with the proton occupying the central position at the nucleus and electrons moving in orbits.

(2) In science analogies are used to make predictions. To give an example. Halley made a prediction about the appearance of a comet in 1758. His prediction was based upon analogy. There is a similarity between the orbit of a comet and the orbit

of a planet, so that, just as the orbit of a planet can be calculated, the orbit of a comet can be calculated. A large comet had appeared at regular intervals in 1305, 1308, 1456, 1531, 1607 and 1682. Halley, therefore, inferred on the basis of analogy of the regularity in movement, that a comet will appear in 1758.

(3) Analogy is also used in technological forecasting. The technological forecaster may compare the technology to be forecast with some similar technology in the past. That is, we might look for historical parallels between the two cases. As an example, one might be interested in forecasting the rate of adoption of some innovations in an industry. Hence the forecaster will examine the past situations where previous innovations were adopted in the same industry, or similar innovations were adopted in other industries. On the basis of these historical parallels, he might forecast the rate of adoption of the innovation he is interested in.

MODEL

What is a Model?

The word model is used as a noun, adjective and verb and in each instance it has a slightly different connotation. As a noun, model is a **representation** in the sense in which an architect constructs a small-scale model of a building or a physicist constructs a large-scale model of an atom. As an adjective model implies a degree of **perfection** or idealization as in reference to a model home, a model student, or a model husband. As a verb 'to model' means to **demonstrate**, to reveal, to show what a thing is like. Scientific models have all these connotations. They are representation of states, objects and events. They are idealized in the sense that they are less complicated than reality and hence easier to use for research purposes. These models are easier to manipulate and 'carry about' than the real thing. The models represent only relevant properties of reality and hence models have simplicity. For example, in a road map, which is a model of a portion of the earth's surface, vegetation is not shown, since it is not relevant with respect to the use of the map. In a model of a portion of the solar system the balls representing planets need not be made of the same material or have the same temperature as the planets themselves.

Literally, the term "model" means representation of structure. But this term has been used in different senses. Let us consider the sense in which this term has been used in formal logic. Formal logic is concerned with sets of axioms and their deductive consequences. The interpretations of these axioms and theorems by a set of entities which satisfy the axioms is called a model. The term model has also been used in the sense of replicas, scale models and analogues. The models may be used in science for expository purposes or even as calculating devices. For example, wind-tunnel experiment, crystellographic models of nerve nets and hydraulic models of economic supply and demand, etc. are devised for expository purposes and used as calculating devices. (A wind-tunnel is a device for producing a carefully controlled stream of air in which the effect on scale models of airplanes or of any component parts involving movement through air can be studied experimentally. It has played a major role throughout the history of aviation. The first wind-tunnel was designed in 1871, in England. Crystellographie and hydraulic models are used for a variety of purposes in the different fields). Some models resemble only in relations between their parts, although their substances are different from the substances of the things modelled. They are, therefore, called analogue machines. The hydraulic models of economic supply and demand consist of pipes carrying coloured fluids. The relations exhibited by such a model enable us to draw conclusions about the economic system. Such machines are often constructed, particularly when there is no known mechanical specification of a system or when specification is very complex. It is, therefore, dangerous to apply to such scientific models those arguments which are valid in connection with logical models of formal systems. The similarity of relations between a model and the system modelled, as discussed above, are called "isomorphism".

The models used in science are called real or iconic models. The iconic model is that of some real or imagined thing or process. Its function is to further our understanding. Toys, for example, are often iconic models. They are similar to other things in some respects. A doll, for example, is often a model of a baby. It is like a baby and can be treated for certain pur-

poses as a baby. Baby-models can be used in training mothers and midwives in baby-handling where it is inconvenient or even dangerous to employ a real baby for that purpose.

In this chapter, we are essentially concerned with the sense of model that is more central to the structure of theoretic science. The models in theoretic science contain some of the features of both logical and replica models. To understand the method of models in theoretic science, we shall first of all consider the conditions of analogy because analogy is associated with them.

Structure of Analogy

Analogies have the following structure:

1. Positive Analogy—that in which A and B are alike.
2. Negative Analogy—that in which A and B are different.
3. Neutral Analogy—those attributes of either A or B about which we have no information as to their being matched in the analogue.
4. In conceiving hypothetical entities such as "force" "molecule" etc., we can examine only one of the entities entering into the analogy, namely, that from which the analogy derives, i.e. its source.
5. The behaviour of the hypothetical entity must be analogous to the behaviour of the real thing which is really causing the phenomena under study.

Scientific Explanation and Analogy

Building a theory is a matter of developing an appropriate analogy. To elucidate this point, let us consider the examples of the science of mechanics having the central concept of "force" and the science of medicine having the central concept of "virus". The "force" and the "virus" are not observable. These concepts are devised by analogy. Forces are analogous to the efforts that people make in shifting things against a resistance Similarly viruses are analogous to the bacteria which had been found to be the causes of many diseases. The concept of "force" and with it the analogy with human effort, is inessential to the science of mechanics because it is possible to understand all the phenomena of motion by using the concept of energy.

But without the concept of virus as a micro-organism, the whole theory of the transmission and cause of a wide range of diseases would be quite different. This theory is an essential part of the understanding of the observation. The virus theory of poliomyelitis is truly a scientific explanation, whereas the systematized laws of mechanics are not. The laws of mechanics are descriptive laws and not explanatory laws, but the virus theory is explanatory in the sense that it explains the cause of disease. Scientific explanation describes the causal mechanism which produces the phenomena.

Theories are the crown of science. The function of theories is to express our understanding of the world. In other words, they explain the phenomena under investigation. Scientific explanation describes the causal mechanism. The causal mechanisms are not always discovered by observation. The hypothetical entities such as molecules or atoms which constitute the causal mechanisms are not discovered initially by observation. The hypothetical entities are first imagined and their attributes are derived by analogy with entities known either by observation or as the hypothetical entities which are valuable in another explanation. In other words, we proceed by the method of analogy to find out the causal mechanism.

In many cases in science we are operating from one term of an analogy only. For example, molecules are analogous to particles in motion, but we cannot experience molecules directly to see how far they are analogous. Since the molecule is an entity which we imagine as being like a particle in motion, we are free to give it just such characteristics as are required for it to fulfil its function as a possible explanatory mechanism for the behaviour of gases. The neutral analogy is just that part of what we know about particles that we do not yet transpose to our imagined thing, the molecule. The molecule is analogous to the particle, not because we find it so, but because we make it so. To use the concept of molecule as an explanatory device we say that a dense collection of molecules must be analogous to the gas. To make the distinction between the relation of molecules to particles of matter and the relation of the laws describing their behaviour to the laws of mechanics and the relation of a dense collection of molecules to gas, we can use

the concept of a model. These relations are not really well brought out in terms of the simple notion of analogy. The concept of model allows us to analyse analogy relationships a good deal more carefully and finely.

Analogy and Model

Explanation can be regarded as attempts at understanding the unfamiliar in terms of the familiar. When the construction and development of explanatory systems are controlled, there is a desire to find and exploit structural analogies between the subject matter under inquiry and already familiar materials. Men do tend to employ familiar systems of relations as models in terms of which initially strange domains of experience are intellectually assimilated. But the felt resemblances are mostly unanalysed similarities—which go beyond their limits and commit serious errors. For example, animistic explanation of physical events are unwarranted extensions of conception from a domain in what their use is legitimate to remain in which it is not. But at the same time it is interesting to note that the apprehension of even vague similarities between the old and the new are also starting points for important advances in knowledge. When reflections become critically self-conscious, such apprehensions may come to be developed into carefully formulated analogies and hypotheses that can serve as fruitful instruments of systematic research.

The history of theoretical science supplies plentiful examples of the influence of analogies upon the formation of theoretical ideas. A number of outstanding scientists admit that models play an important role in the construction of new theories. For example, Huygens developed his wave theory of light with the help of suggestions borrowed from the already familiar view of sound as a wave phenomenon. Black's experimental discoveries concerning heat were suggested by his conception of heat as a fluid, and Fourier's theory of heat conduction was constructed on the analogy of the known laws of the flow of liquids: the kinetic theory of gases was modelled on the behaviour of an immense number of elastic particles, whose motions conform to the established laws of mechanics; the conception of a potential function, first developed in the mechanics of point-masses, was extended by analogy into theories of hy-

drodynamics, thermodynamics and electro-magnetism and nineteenth century theories of electricity and magnetism were built in analogy to the mechanics of stresses and strain in an elastic solid. In these examples, the model served both as a guide for setting up the fundamental assumption of theory, as well as a source of suggestions for extending the range of their application.

Maxwell was clearly aware of analogies in the conduct of physical research and in the formulation of theories. Maxwell was the first person to propose a mathematical formulation of Faraday's ideas on lines of force. He gave an instructive account of the way in which analogies can be exploited in science. He described a "physical analogy" as that partial similarity between the laws of one science and those of another which makes each of them illustrate the other". He noted, for example, that the change in the direction of light when it passes from one medium to another is identical with the altered direction of a particle when it passes through a narrow opening in which strong forces are acting. **Although the analogy holds only for the speed of motion, he nevertheless regarded the analogy to be useful as an artificial method for the solution of a certain class of problems.** Maxwell had also cited the analogy between the theory of gravitation and the theory of heat conduction. He explained: "The laws of conduction of heat in uniform media appear at first sight among the most different in their physical relations from those relating to attractions. The quantities which enter into them are temperature, flow of heat, conductivity. The word force is foreign to the subject, yet we find that the mathematical laws of the uniform motion of heat in homogeneous media are identical in form with those of attractions varying inversely as the square of the distance. We have only to substitute source of heat for centre of attraction, flow of heat for accelerating effect of attraction at any point, and temperatures for potential, and the solution of a problem in attractions is transformed into that of a problem in heat." Maxwell further observes that: "The conduction of heat is supposed to proceed by an action between contiguous parts of a medium, while the force of attraction is a relation between distant bodies, and yet, if we know nothing more than is express-

ed in the mathematical formulae, there would be nothing to distinguish between the one set of phenomena and the other.

The two subjects do indeed assume quite different aspects if additional facts are introduced. But the resemblance in mathematical form between some of the laws for these distinct subjects is useful 'in exciting appropriate mathematical ideas'. It was through the use of analogies of this kind that he developed his mathematical representation of the phenomena of electricity, employing as model for this purpose the mathematical analysis of the motions of incompressible fluids."

Maxwell's discussion suggests a classification of analogies into two broad types, which we may call "substantive" and "formal" analogies. In substantive analogies, a system of elements possessing certain already familiar properties, assumed to be related in known ways as stated in a set of laws for the system, is taken as a model for the construction of a theory for sums second system. This second system may differ from the initial one only in containing a more inclusive set of elements, all of which have properties entirely similar to those in the model; or the second system may differ from the initial one in a more radical manner, in that the elements constituting it have properties not found in the model (or at any rate not mentioned in the stated laws for the model).

The various atomistic theories of matter illustrate the exploitation of this type of analogy. The fundamental assumption of the kinetic theory of gases, for example, are patterned on the known laws of the motions of macroscopic elastic spheres, such as billiard balls. Similarly, part of electron theory is constructed in analogy to established laws of the behaviour of electrically charged bodies. In this type of analogy, the system employed as a model is frequently a set of visualizable macroscopic objects. Indeed, when physicists speak of a model for theory, they almost always have in mind system of things differing chiefly in size from things that one at least approximately realizable in familiar experience, so that in consequence a model in this sense can be represented pictorially on imagination.

In the second or formal type of analogy, the system that serves as the model for constructing a theory is a one familiar

structure of abstract relations, rather than as in substantive analogies, a more or less visualizable set of elements which stand to each other in familiar relations. Mathematics frequently employ such formal models in developing some new branch of the subject.

Purposes of Models

Models are used for certain definite purposes and, in science, these purposes are: (1) logical: they enable certain inferences which would not otherwise be possible, and (2) epistemological: that is, they express and enable us to extend our knowledge of the world.

Source and Subject of a Model

To sort out the above mentioned purposes rationally, a distinction will have to be made between the source and the subject of a model. Take an example of a doll. A doll is a model of a baby and also modelled on a baby. Its source is the real thing, the baby, while its subject is, in this case, also a baby. Its source and subject are the same. Such models are called **homoeomorphs.** But when one is using the idea of the molecules as the basis of a model of a gas, the molecule is not modelled on gas. The molecule is modelled on something quite different, namely the solid, material particles, whose laws of motion are the science of mechanics. Such a model for which the source and subject differ is called a **paramorph.** Science employs both homoeomorphs and paramorphs. The proper use of models is the very basis of scientific thinking.

Types and Functions of Model

Scientific models are utilized to accumulate and relate the knowledge we have about different aspects of reality. They are used to reveal reality and more than this to serve as instruments for explaining the past and the present and for predicting and controlling the future. What control science gives us over reality, we normally obtain by application of models. They are our descriptions and explanations of reality. A scientific model is in effect, a set of statements about reality. These statements may be factual, law-like, or theoretical.

In science as well as in ordinary activity, we employ different types of models: **the iconic model, the analogue and the symbolic model.** Iconic models are large or small scale representations of states, objects or events. Because they represent the relevant properties of the real thing by those properties themselves with only a transformation in scale, iconic models look like what they represent. For example, road maps and aerial photographs represent distances between and relative positions of places and routes between them. With respect to these relevant properties such maps or photographs look like the real thing: they differ from it with respect to these properties only in scale.

In most cases if we want to show the third dimension elevation on a map we do not produce a three dimensional map, rather we resort to colours or to contour lines which by their distances apart convey information about grades, or, if we want to show the kind of road, we use colour or shading and provide an appropriate legend which explains the transformation of properties. In these cases, one property is used to represent another, and hence the necessity of a legend. In such cases the model is an analogue.

An electric system may be represented by a hydraulic system. In such a case, the flow of water may represent the flow of electric current. The slide rule is a familiar analogue in which quantities are represented by distances proportionate to their logarithm. Graphs in which such properties as costs, time, number of people and percentages are plotted are also analogues. Finally there are symbolic models in which the properties of the thing represented are expressed symbolically. Thus a relationship shown in a graph (as an analogue) can also be shown in an equation. The equation is a symbolic model. Models in which the symbols employed represent quantities are usually called mathematical models. Iconic models are the most specific and concrete of the three types of models but are usually the most difficult to manipulate for purposes of determining the effect of changes on the real thing. In the analogue easier-to-manipulate properties are usually substituted for the real ones. As a consequence such models are more abstract and general. For example, if we examine a graph in which distance

and time are plotted, it is not likely that we can identify the phenomena involved unless the graph is labeled appropriately Symbolic models are the most abstract and general and are the easiest to manipulate. In general, the amount of analysis required to construct a model is inversely related to the case of manipulating it, once it has been constructed. Science employs all three types of model. In general, however it uses iconic models and analogues a preliminary to the development of symbolic models. Iconic models and analogues are also used widely by scientists for pedagogical purposes, since they are easier to understand.

Analogy and Analogue

In both an analogy and an analogue we use one situation as a model of another. The difference lies in what we know of the correspondence of the models to the 'real' situation. In an analogy we know only that the two situations have certain properties in common, we know nothing about the correspondence of the structure of the two situations. That is, in an analogy we do not know the function f, which relates the outcome to the variables, and hence do not know how well or badly it corresponds to the structure of the real situation. In an analogue we self-consciously design into the model, a structure that is based on analysis or experimentation, we believe to correspond to some acceptable degree with the real one.

Models and Hypotheses

Hypotheses serve as models in a theoretical science. This fact has been clearly brought out by Hertz. According to Hertz, "Hypotheses are pictures or models which we make for ourselves of certain phenomena or groups of phenomena, in order to gain a better general view of them and to see them more clearly." A hypothesis is good when this picture or model does not merely represent correctly the characteristics of the particular group of experimental facts, but when it further exhibits characteristics which lead us to new facts. In other words, "the consequences of the pictures further prove to be pictures of the consequences." Hence. Mach distinguishes a 'thought-economy value' and a 'heuristic value' of hypotheses. Both Hertz and Mach. however, clearly reject any intrinsic value in real knowledge of

these pictures or models. Let us now consider, in detail, the role of models in theoretic science.

Models in Theoretic Science

Theoretic models are associated with the structure of theories. Unlike logic, the notion of a model is not dependent on prior development of a formal theory. The models in theoretic science are dependent on some system. In other words, models of this kind provide explanation in terms of something already familiar and intelligible. For example, the light phenomena had been explained in terms of light corpuscles or a corpuscular model. It was later on abandoned. Bohr's model of the atom refers to the theory that was proposed to account for certain quantum phenomena. (Each unit of the energy is called quantum). In cosmology, we use the world models which are theories of the structure of the universe. This use of the term model is not applicable to the theory which is widely accepted or fully established. For example, we cannot say that there is a wave model of sound because a theory of sound in terms of wave motion is fully established and is even regarded as factual rather then theoretical.

Basically, the theoretic model exploits some other well established systems such as mechanism or a familiar empirical theory, from another domain. The less well established systems under investigation may be called the explanandum. The theoretical model carries with it "surplus meaning" derived from the familiar system. The theoretical model conveys associations and implications that are not completely specifiable and that may be transferred by analogy to the explanandum. Further developments and modifications of the explanatory theory may therefore, be suggested by the theoretical model. As the theoretical model is richer than the explanandum it imports concepts and conceptual relation not present in the empirical data alone.

The model is first proposed because there is some obvious positive analogy between it and the explanandum. In addition to the known positive analogy, there is a set of properties of the model whose positive or negative analogy is not yet known. We call this set as the neutral analogy. Exploitation of the model consists in investigating this neutral analogy and in allowing the neutral analogy to suggest modifications and developments

of the theory that can be confirmed or refuted by subsequent empirical tests.

A theory is often nothing but the description and exploitation of some model. The kinetic theory of gases is nothing but the exploitation of the molecule model of gas and that model is itself conceived by reference to the mechanics of material particles. A theory has a very complicated structure having the relations of analogy. The gas molecule is analogous to the material particle and the dense collection of molecules is analogous to whatever a gas really is, and both these analogies are tested by the degree to which the model can replicate the real gases. Since we do not know the constituents of a gas independently of our model, we can scarcely be in a position to declare any negative analogy between the model and the gas of which it is a model.

Here are some examples which show the different ways in which the question of the reality of an iconic model can be pursued. Darwin's Theory of Natural Selection provides an excellent example of the use of iconic model building to devise a hypothetical mechanism, to account for the facts which were known to naturalists. Darwin did not know what were the processes by which change in the animals and plants of nature come about. So he constructed a model. He knew very well that there is change in domestic animals and plants which is due to the fact that the breeder selects those plants and animals from which he wishes to breed. After several repetitions of selection, a creature quite different in appearance can be derived from appropriately chosen individuals solely by breeding. There is a variation in nature and Darwin conceived of a process analogous to domestic selection which could be a model of whatever process was really taking place in nature. He called this process, modelled on domestic selection, natural selection.

Now, consider the example of model building which has taken place in the theory of electrical conduction. Somehow, the electrons in metals are responsible for conduction of electricity in metal. Drude produced a very successful model of the mechanisms of conduction by supposing that there were free electrons in metal which behaved like the dense collection of molecules (which we have seen as most successful model of

gas). From supposing that the electrons were like a gas confined within a container, he was able, with very supplementary assumptions to work out an explanation of the known laws of conduction. He showed that a dense collection of electrons obeying the gas laws would behave analogously to a conductor. Here the model is modelled on another model, and is a model of truly unknown mechanism, the mechanism of the conduction of electricity in metals.

If knowledge is pursued according to this method, it will tend to be stratified. It falls into two strata. In one stratum, the facts to be explained are set out and their patterns described. In the underlying stratum, we may imagine or describe the causal mechanism. The process of stratification continues until the most fundamental relations recognized in each era are reached.

SUMMARY

A generalization is a statement whose scope is wider than the evidence for it. Both simple enumeration and analogy make generalizations. Simple enumeration consists in arguing that what is true of several instances of a class is true of all the instances of a class. For instance, we observe some roses. We find that these roses possess thorns. On the basis of this observation, we generalize 'all roses possess thorns'. Generalization established by simple enumeration has certain characteristics.

(1) Generalization is established on the basis of uniform or uncontradicted experience.

(2) Generalization is established on the basis of the observation of some instances and not all the instances of a class.

(3) Generalizations are not based upon the scientific analysis of properties of the instances observed.

(4) The conclusions of simple enumeration are always probable and never certain.

(5) Of course, these conclusions differs in other probability.

Simple enumeration plays its role in scientific investigation. The generalizations arrived at by simple enumeration suggest scientists the hypothesis. Simple enumeration suggests causal relation. As grumley puts it, "The condition that two phenomena are always or very frequently connected seems sufficient ground of entertaining the hypothesis that they are causally related". Simple enumeration is very useful in the initial stages of scientific investigation.

Analogy is an argument from partial resemblance to further resemblance There are three stages in an analogical argument: (1) Two things resemble each other in certain respects. (2) One of them possesses a

certain additional quality. (3) On the basis of the first two stages as the evidence, we arrive at the conclusion that the second thing also possesses the additional quality.

Analogy depends upon the qualities or characteristics. On the basis of these characteristics, we have three kinds of analogy: (1) Positive analogy which consists of likenesses or similarities between two instances or processes, (2) Negative analogy which consists of unlikenesses or differences between two instances or processes, and (3) Neutral analogy which consists of unknown characteristics. Neutral analogy means the features which are not known to be either likenesses or unlikenesses.

The conclusions of analogical arguments are probable, but the degree of probability is not same in every argument. The degree of probability depends upon certain conditions. They are: (1) When the similarities between two instances are more important, the analogical argument has a high degree of probability. (2) when the differences between two instances are more important, the analogical argument has a low degree of probability. (3) The generalization should not try to prove too much.

Analogy is very useful in science. Analogy suggests hypothesis on which scientific investigation depends. Many important scientific investigations are made on the basis of analogy. Analogy is very useful in scientific predictions. Scientists use analogy even in technological forecasting.

The term model has several meanings. Ordinarily it means representation of structure. In formal logic it has been used for the set of entities which satisfy the axioms of logic. It may also mean replicas, scale models or analogues. Models are used for expository purposes and as calculating devices. The similarity of relations between a model and the system modelled is called isomorphism.

Models used in science are called iconic models. They represent some real or imagined thing or process. Its function is to extend our understanding. The models in theoretic science contain some of the features of both logical and replica models

Building a theory is a matter of developing an appropriate analogy. The function of theory is to explain and scientific explanation consists in describing causal mechanisms. The causal mechanisms are not always discovered by observation. The hypothetical entities such as molecules or atoms are first imagined and their attributes are derived by analogy with entities already known. We proceed by the method of analogy to find out the causal mechanism.

Molecules and the particles in motion are analogous but we cannot observe molecules. So we are free to give those characteristics which are in the particles in motion but not yet transposed to our imagined thing, viz., the molecule. To use the concept of molecule as an explanatory concept, we say that a dense collection of molecules is analogous to gas. The different relations between these concepts can be explained by notion of analogy.

Models are used in science to serve logical and epistemological purposes. They enable certain inferences which would not otherwise be possible and they express and enable us to extend our knowledge of the world. To distinguish between these purposes we must know the use of the source and the subject of a model. When the source and the subject are the same in a model as in the case of a doll whose source and the subject is a baby, it is called a homoeomorph model. When the source and the subject of model are different, it is called a paramorph model. For example, a molecule may be a model whose source may be its material particle and its subject may be a gas. Science employs both homoeomorph and paramorph models. The proper use of models is the very basis of scientific thinking.

The models in theoretic science are dependent on some system which is familiar and intelligible. It is not applicable to the theory which is widely accepted and has become factual. The theoretic model carries with it "surplus meaning" derived from the familiar system. Further developments and modifications of the explanatory theory may be suggested by the theoretic model.

The obvious positive analogy makes us propose a model. The exploitation of a model consists in investigating the neutral analogy and to suggest modifications and developments of the theory which can be confirmed or refuted by subsequent empirical tests. Kinetic theory of gases is the exploitation of the molecular model of gases and that model is conceived by reference to the mechanics of material particles. The concept of a paramorph model can be used in the analysis of the following theories. (1) Darwin's theory of Natural Selection. (2) Drude's explanation of electric conductivity.

Organised in this way, the knowledge is stratified in: (1) non-random patterns which require explanation, and (2) explanation is provided by the description of causal mechanism, in general unobservable, whose behaviour generates the observed pattern. This process of stratification continues until the most fundamental relations recognized in each era are reached.

EXERCISES

1. What is induction by simple enumeration? Is it ever conclusive?

2. What is the role of induction by simple enumeration in scientific investigation?

3. Bring out the nature of simple enumeration as a way of arriving at generalization.

4. What is analogy? Distinguish between sound and unsound analogy.

5. Explain and illustrate positive analogy, negative analogy and neutral analogy.

6. What is the role of analogy in science?

7. State and explain the conditions of a sound analogical argum nt.

8. Write short notes on: (a) Inductive generalization. (b) Positive analogy. (c) Negative analogy. (d) Neutral analogy.

9. Explain the different meanings of the term model.

10. Explain the following: (1) Isomorphism. (2) Iconic model. (3) Homoeomorph. (4) Paramorph. (5) Scientific explanation. (6) Analogies used in science.

11. "Building a theory is a matter of developing an appropriate analogy." Explain.

12. What is the necessity of the method of a model?

13. What are the purposes of a model?

14. How are models used in theoretic science? Explain in detail.

15. Explain an example in which a paramorph model has been used

16. Give an example of homoeomorph model.

17. "The models in science are dependent on some systems which are familiar and intelligible." Explain.

Chapter Five

ABSTRACTION AND GENERALISATION

Language and abstraction — Abstraction and generalisation — Method of extensive abstraction — Occam's razor.

Science begins with sensible facts and ends with abstractions. The scientist begins with particular sensible facts in order to obtain generalization of increasing abstraction. We shall consider the principles involved in this process. The problem of abstraction and generalization is of great importance in the discussion of scientific method. Let us, therefore, consider, step by step, the entire issue.

LANGUAGE AND ABSTRACTION

The sole function of language for science is to communicate information. Naturally, the scientist finds it necessary to devise a scientific or precise terminology. But even a scientist does not achieve the impersonality of thought which is necessary for exactness of statements. Moreover, no thinker or no scientist can use language in order to communicate that is exact, precise and without the context of his experience.

It is impossible to think without signs. A word which is a special kind of sign cannot express all the characteristics of a given situation about which we think. For example, the word Maharashtrian used in a given situation does not express all the characteristics of Maharashtrians. Within the given situation itself we may attend to only some of the characteristics which are apparently related to the occasion of thinking.

When we think about a situation, we disconnect it, at least partially, from other situations with which it is, in fact, connected. For example, when we refer to an object as 'this is a table' we disconnect it from other things or pieces of furniture.

but this particular table is connected with the other pieces of furniture or the word table is connected with the class of tables. In other words, it involves both analytic and synthetic selection. But it must be remembered that no communicable description is adequate in all its details, because to think is to go beyond what is sensible. According to Prof. A. N. Whitehead, "to be abstract is to transcend particular concrete occasion of actual happenings." The particular concrete occasion is said to be transcended because what is abstract has relevance to other occasions than the given occasion. When we state the general characteristics of things such as 'table' we are abstracting. These characteristics are incapable of being represented by what is sensibly presented. The general characteristics are nothing but an arbitrarily devised set of signs. They are needed for the development of thought.

ABSTRACTION AND GENERALIZATION

Abstraction presupposes analysis. To abstract means to select from a couple of situations, elements that are not given in isolation. Abstraction may be of various degrees. For example. the proposition, 'This table is brown'. has a lower degree of abstraction than the abstraction contained in the proposition. 'Tables are brown'. The propositions of the kind resembling the latter one, are called empirical generalizations. It is with such empirical generalizations that science begins. The use of class names indicates that a generalization has been made. For example, the word 'crow' indicates that it is a set of individuals possessing certain properties in common. Many such classes must be recognized before science is possible. In the classification of crows, the relations with other classes is involved. The ordered relations of classes yield the propositions such as "crows are birds". This is a general proposition. Propositions of this type express a relation between characters. Hence generality involves abstraction. So we may say that science takes notice of particular occasions only in order to verify general propositions. A science in the classificatory stage involves abstractions that are expressible in general propositions. The characters shown to be related are given in sensible experience and, therefore, they are called material constituents. When there is

complete abstraction from all material constituents, the proposition is completely formal.

When there is greater disconnection from any given set, of particular occasions, the abstraction becomes more complete. When the abstraction becomes more and more complete, the method of science passes from classification to causal investigation and from causal investigation to meaurement. The most complete abstraction is achieved in mathematics. In other sciences, there cannot be complete abstraction. The sciences in which classification plays an important part have achieved least complete abstraction. For example, social and biological sciences have achieved least abstraction.

The Method of Extensive Abstraction

The method of extensive abstraction is concerned with the problem of applying mathematical abstractions to the perceptible objects of the sensible world. Prof. A. N. Whitehead shows in detail that the principle of convergence to simplicity provides a method of effecting the connection between the mathematical abstraction and the perceptible objects of the sensible world. He calls it the method of extensive abstraction.

The problem is to exhibit mathematical concepts, e.g. points, instants, particles, monetary configurations, etc. as logical functions of what is given in sense. This is exhibited on the basis of the principle of convergence to simplicity with diminution of extent. According to this principle, any complex occurrence can be regarded as analysable into an arrangement of homogeneous units the laws of whose behaviour can be expressed quantitatively. Thus the manageable complexity of perceptible obpects is reduced to simple laws. When this stage has been reached, the cause and effect themselves come to be apprehended as in constant change; causal laws are replaced by mathematical functions expressing tendencies. Scientific laws, thus expressed, are very different from the causal uniformities of early sciences. The generalization that heavy bodies fall to the ground seems very different from the statement that every particle of matter attracts every other particle a force directly proportional to their mass and inversely proportional to the square of their distance. This latter statement is reached

by carrying further the analytical method employed in the discovery of qualitative uniformities and by applying it more precisely and systematically in accordance with the principle of convergence to simplicity with diminution of extent.

Let us consider the problem of points. The common man regards it as a limit of a line or of an area. He knows that the distance can be measured by a foot-rule which connects any two points between two big objects. It makes the notion of distance vague. If he takes the smaller objects, the notion of distance will become less inaccurate. But however lower or smaller the objects may be they will always have some size. The common man knows that points have no magnitude and it is the limit of a line that ends at the point. But we are never sensibly aware of the point. If we divide a line into smaller and smaller lines, each line will have a length, however small it may be. It will be part of the line. Any line can be split up into a finite number of points in a line. It is something of a different kind and not a part of the line in the same sense in which the smaller lines into which it is divided are parts of the line. In other words, a point is an ideal limit. It is not a part of an area or a volume, and yet it is contained in an area or a volume. The value of this method consists in showing abstract deductive system can be applied to the world presented in sense.

Abstraction and Occam's Razor

Suppose it is not necessary to define a 'point' by the method of extensive abstraction. It may, again, give rise to the question: "What kind of entity a point is supposed to be?" A philosopher who accepts a theory of absolute space will regard a point as a particular or individual but imperceptible entity. On this view, a point will be imperceptible not only because it is small, but because it is unextended. So its existence and nature remain hypothetical. Many philosophers have, therefore, refused to admit that points exist. If this view is accepted, it would be difficult to understand the success of physics which uses points in the formation of constructive descriptions of what is perceptible.

Suppose, that points exist. Naturally, the properties of point must be laid down in the definition. Suppose, again, that points

do not exist. Then the definition provides us with the same set of logical properties. On either hypothesis, the definition yields everything for which points are required in mathematics. So even if there were no points, the reasoning in which they enter would not be invalidated. It is, therefore, safer to neither assert nor deny that points exist. It seems reasonable to refrain from making any assertion.

This cautious procedure is in accordance with the principle commonly, though wrongly, attributed to William of Occam, after whom it is named "Occam's Razor". The principle is "Entities must not be multiplied without necessity". As it stands this advice is not very useful. All depends upon how "without necessity" is to be interpreted. Sometimes, it is difficult to ascertain whether an entity is or is not necessary. For example, points in some sense are necessary. But if it is acceptd that whatever is observable has existence, the points will have to be regarded as the entities having no existence. For such entities Bertrand Russell gives the name "conventional fictions". But fiction is that which is invented and which corresponds to nothing.

By the method of extensive abstraction we can say that points do exist but they are not simple particulars as believers in absolute space have supposed. Points are, on the contrary, complex structures. They may be regarded as convenient structures which are to be found in nature. Bertrand Russell has made extensive use of Occam's Razor to cut away "points regarded as simple particulars". It is a useful methodological principle. Russell named it as the principle of construction versus inferences. When, to account for a set of facts we have to assume an imperceivable entity, we should not infer that entity in question exists. On the contrary, we should seek for something having the required property. This is what has been done by the definition of points by the method of extensive abstraction. The principle of "construction versus inference" suggests that one should carry on his analysis as far as possible until every concept is shown to be a logical function of what is sensibly perceived.

SUMMARY

To think is to go beyond what is sensible. To be abstract is to go beyond particular concrete occasion of actual happenings. So all thought involves abstractions. When we abstract, we state the general characteristics of things, which are common with other things.

Abstraction presupposes analysis. It involves the method of selection of elements that are not given in isolation. Such elements can be related with the other elements. Such relationship between the two abstract terms gives empirical generalisation. Science begins with such generalisation. The use of class-names indicates that the generalisation has been made.

The ordered relation of classes gives a general proposition. Generality involves abstractions. A science in the classificatory stage involves abstractions that are expressible in general proposition. The basis of such general proposition is the material constituents of the characters. When there is complete abstraction from all material constituents, the proposition is completely formal.

When abstration becomes more and more complete, the method of science proceeds from the stage of classification to causal investigation and then to measurement. The most complete abstraction is achieved in mathematics. The least number of abstractions are formed in social and biological sciences.

The method of extensive abstraction is concerned with the problem of applying mathematical abstractions to the perceptible objects.

The principle of convergence to simplicity provides a method for it. It is also called as extensive abstraction. The principle of convergence to simplicity with diminution of extent, exhibits that any complex occurrence can be regarded as analysable into homogeneous units. The law of those units can be expressed quantitatively. The complexity is reduced to simple laws. It shows that the cause and effect are in constant change. The causal laws are replaced by mathematical functions, expressing tendencies. The value of this method consists in showing how abstract deductive system can be applied to the sensible world.

EXERCISES

1. Show the relationship between abstraction and generalisation.

2. Explain the method of extensive abstraction.

3. Write notes on: (a) Language and Abstraction. (b) Degrees of Abstractions. (c) Function of Abstraction. (d) Abstraction and Occam's Razor.

Chapter Six

HYPOTHESIS: THE ART OF SCIENTIFIC INVESTIGATION

Nature of hypothesis — The hypothetico-deductive method — How hypothesis originates — Conditions of a good hypothesis — Kinds of hypothesis — Verification of hypothesis — Proof of hypothesis — Fact-hypothesis-theory-law — Place of hypothesis in science.

The aim of scientific inquiry is to establish causal relationship. The scientist is not interested in merely collecting and describing facts. His aim is to explain them. He seeks to explain the facts by discovering and connecting links. Man cannot create order in Nature, he can only look for it, or try to discover it. 'Problem' is the starting point of any scientific investigation. When an event takes place, the scientist asks "why has the event happened?" He proceeds to formulate a tentative supposition or answer. This supposition is a guess as to what could explain the puzzling situation. Such a tentative supposition, advanced to explain the observed puzzling facts, is called a hypothesis. If such hypotheses are not advanced, a scientist cannot go ahead with the investigation of his problem. In the absence of direction which hypotheses provide, the scientist would not know what facts to look for and what order or link to search for among them. Thus, hypotheses guide the scientist through the ocean of facts, to see and select only those facts that are relevant to the problem. The scientist has first to identify the problem. Then he has to make a guess about the possible answer. Werkmeister rightly observes, "The guesses he (scientist) makes are the hypotheses which either solve the problem or guide him in further investigation."

Mill defines hypothesis as follows: "An hypothesis is any supposition which we make (either without actual evidence, or

on evidence avowedly insufficient) in order to endeavour to deduct from it conclusions in accordance with facts which are known to be real; under the idea that if the conclusions to which the hypothesis leads are known truths, the hypothesis itself either must be, or at least is likely to be true." Cohen and Nagel state, "We cannot take a single step forward in any inquiry unless we begin with a suggested explanation or solution of the difficulty which originated it. Such tentative explanations are suggested to us by something in the subject-matter and by our previous knowledge. When they are formulated as propositions, they are called hypotheses."

It is clear now that a hypothesis is a provisional supposition accepted as a possible and probable explanation of the phenomenon under investigation. It has the element of tentativeness. Hypotheses are common features of our everyday life as also of a scientist's research. The role of hypotheses in research can be discussed more effectively if we consider some examples of discoveries which originated from hypotheses.*

Suppose you are motoring with your friends to a neighbouring city. On your way to the destination, the engine of your car suddenly sputters and dies. What can be the trouble? Your first thought concerns the supply of petrol. Your petrol gauge is not working. This idea about the lack of pethol is your first hypothesis about the source of trouble. But you remember that you had filled the petrol tank on the day before and had not used the car since then. So you reject your first hypothesis. Your second hypothesis is that the ignition has failed, for ignition and fuel are the two most important elements for the running of a petrol engine. You have learnt in the past how to test the ignition, and you proceed to do so. You find that the ignition seems in good condition. Your next hypothesis is that there is a clogged gas line to the carburettor, for you recall a friend having had the same trouble. Your test, however, shows the gas line is clear, but there is no petrol in it. This fact leads you to reexamine your first hypothesis that the tank is empty. You think in quick succession of things that could have happened to your supply. Thieves could have drained your tank. But why

* J. P. Guilford — *General Psychology.*

did they not take it all, and how could they have entered your garage which is guarded by a watchman? This is what is known as checking of a hypothesis on the symbolic level. You re-examine the tank and find it empty. A new question arises: how did you lose your petrol? The cap is on tight, so a careless filling-station is not to blame. Could there be a hole in the tank? Then you remember running over an object on the road a few miles back that gave a sharp thumping sound as you passed over it. You probably would never have recalled this fact as long as you lived if it had not fitted into picture so neatly. A close examination of the tank shows a small hole in it, resulting in a slow leak. Your question—"Why did the engine die?"—is anwered.

In Western Australia and Great Britain occurs a nervous disease of sheep. This disease is known as swayback. The cause of this disease puzzled investigators for many years. Then H. W. Bennetts hypothesised that the disease might be due to lead intoxication. To see whether this hypothesis was correct, he treated some sheep with ammonium chloride which is an antidote to lead. The first trial with this gave promising results. However, the results were not borne out by subsequent trials. This suggested to Bennetts that the disease might be due to the deficiency of some mineral which was present in small amounts in the first batch of ammonium chloride. This hypothesis made Bennetts proceed further in his investigation. And Bennetts was finally able to show that the disease was due to the deficiency of copper.

This method of investigation is also called **"the Hypothetico-Deductive Method"**.

1. The Hypothetico-deductive method, as the very name suggests, is not an absolutely inductive method. It makes use of both inductive and deductive reasoning.

2. This method is used extensively in scientific investigation. Experience shows that this method can be profitably used in everyday life to solve the ordinary non-scientific problems also.

Stages in the Hypothetico-Deductive Method

This method has four main stages:

1. **Feeling of a problem**: A scientist's observation reveals some puzzling facts. These facts pose a problem.

2. **Formulation of a hypothesis**: A tentative supposition is made to explain the facts which call for an explanation. The supposition is made on insufficient evidence. We must remember that, at this stage, some past experience is necessary to pick up the significant aspects of the observed facts. Without previous knowledge, the investigation becomes difficult, if not impossible. The present circumstances also force the scientist to think of certain possible solutions. Both past experience and present experience combine to influence the selection and rejection of some solutions even before they are actually tried out.

3. **Deductive development of hypothesis**: At this stage, a scientist makes use of deductive reasoning. He constructs a deductive argument by supposing that the hypothesis is true. He uses the hypothesis as a premise, and draws a conclusion from it. In other words, he deduces implications from the hypothesis.

4. **Verification of hypothesis**: This consists in finding whether the conclusion drawn at the third stage really takes place. In other words, verification consists in finding whether the hypothesis agrees with facts. If the hypothesis stands the test of verification, it is accepted as an explanation of the problem. But if the hypothesis does not stand the test of verification, the scientist is thrown back upon the search for further solutions.

A hypothesis thus stands somewhere at the midpoint of research; from here one can look back to the problem and also look forward to data. If the hypothesis holds good under all circumstances, it may be elevated to the category of a theory, or even, if sufficiently profound, a law.

How a Hypothesis Originates

The need for a hypothesis arises when there is a puzzling situation. A scientist formulates a hypothesis and seeks to explain the situation. This formulation of a hypothesis is the work of an inventive genius. The process of formulation of a hypothesis cannot be brought under any general rules. No set of suggestions can be laid down to enable the scientist to come with fruitful hypotheses in particular case. The formulation of

hypotheses is purely an individual affair. It is very difficult to ascertain when it would be suggested, how it would be suggested, and to whom it would be suggested. As Larmour says, "Ideas emerge dimly into intuition, come into consciousness, nobody knows from where, and become the material on which the mind operates."

Taking into consideration the above mentioned personal aspects, Cohen and Nagel state, "Hypotheses are suggested to an inquirer by something in the subject-matter under investigation and by his previous knowledge of other subject matters No rules can be offered for obtaining fruitful hypothesis, any more than rules can be given for discovering significant problems." Though no rules can be offered for the formulation of a hypothesis, from the history of science certain situations can be described that led to the formulation of hypotheses. The following are some of the ways in which hypotheses come to be suggested.

(1) Imagination plays a very important role in the act of formulating a hypothesis. In fact, no hypothesis can be formulated without imagination. A hypothesis is a child of a creative mind gifted with imagination. Therefore, Whitehead writes, "The true method of discovery is like the flight of an aeroplane. It starts from the ground a particular observation, it makes a flight in the thin air of imaginative generalization, and it lands for the renewed observation rendered acute by rational interpretation." Many a person had seen falling of an apple, but it was reserved for the imagination of Newton to discover and establish the law of gravitation.

(2) Wide knowledge is another source of hypothesis. Though imagination plays an important role in the formulation of a hypothesis, we must not forget that imagination must be backed by a competent knowledge of relevant facts. If a hypothesis has no basis in relevant facts, it will be useless. A scientist, whose mind is well-versed and conversant with the facts and laws relating to the domain of his special study, is in a position to formulate a fruitful hypothesis. Existing knowledge in the science points to problems still unsolved, and a logical deduction from these leads to new hypotheses. The history of science is full of instances of discoveries made just because the 'right' per-

son happened to make the 'right' observation on the basis of previous knowledge of the subject. Our information determines our conclusions. A hypothesis that a scientist formulates depends upon what particular facts he has at his command. Pasteur was considered to be the right man to investigate the question of the proper cure for the disease of silk worms, because he had a wide background of knowledge about diseases. Newton emphasised the importance of the knowledge of facts. He declared: "Hypothesis Non Fingo". This means "I do not imagine hypothesis." Newton attributed his discoveries to industry, labour and patient thought. Thus, imagination must be backed up by rich knowledge of facts. Then only can a scientist hit upon a fruitful hypothesis.

(3) Some hypotheses spring from analogy. Analogy is an inference based upon resemblance. There are three steps in an argument from analogy. Firstly, two things resemble one another in some characteristics. Secondly, one of the things possesses a further additional characteristic. Thirdly, on the basis of partial similarity, we frame a hypothesis that the additional characteristics possessed by one is also possessed by the other. Analogies suggest hypotheses which sometimes lead to important discoveries. The communication models in the social sciences speak so much of the importance of analogies as sources of fruitful hypotheses. Thus, plant ecology suggested to sociologists the hypothesis that similar human types or activities may be found occupying the same territory. Malthus' population theory, that population increases faster than food supply, suggested to Charles Darwin the problem of the struggle for the survival of the species. There is a large number of such examples. Analogy is very suggestive, but we must be on our guard not to accept models from other disciplines, without a careful scrutiny of the concepts in terms of their applicability to the new frame of reference.

(4) Simple enumeration is another source of hypotheses. Simple enumeration consists in arguing that what is true of several instances of a class, is true of all the instances of a class. This argument is based upon uniform or uncontradicted experience. We observe that, so far as our experience goes, two things always go together. We find that two attributes are associated.

Of course, we do not know whether there is any causal connection. On the basis of the constant association, we suppose that there is some causal connection. We then proceed to formulate a hypothesis. It is our common experience that camels are brown, crows are black, children of blue-eyed parents are blue-eyed, etc. Sometimes a scientist starts with such experiences in investigation.

(5) A particular cultural environment in which a science develops furnishes many of its basic hypotheses. Cultural environment, thus, is very important. Only certain hypotheses and not others engage the attention of scientists in particular culture. In India, religion and custom dominate our way of life. This factor has its impact on economic values and individual's participation at various walks of life. This situation gives rise to a large number of hypotheses—economic, sociological, political, cultural, etc. According to Goode and Hart, the American emphasis on personal happiness has had a considerable effect upon social science in the U.S.A. In America, in every branch of science, the problem of personal happiness has come to occupy a central focus of attention. Happiness has been correlated with income, education, occupation, social class, etc. This cultural emphasis upon personal happiness has given rise to an indefinite number of hypotheses for American Social Science.

(6) New hypotheses may result when an existing theory or law fails to explain certain facts. This has happened in the case of the discovery of Neptune. The law of gravitation was established and it explained the planetary motion. But a new problem arose. That is, Uranus deviated from its orbit. This problem could not be explained by the law of gravitation. Therefore, the scientists advanced the hypothesis that some other planet must be attracting Uranus to itself. And this hypothesis was proved to be correct by the discovery of Neptune in 1846. Thus, exceptions to the accepted theory sometimes lead to the formulation of hypotheses.

(7) New hypotheses may result from accidental discoveries that are followed up. For example, the laws of internal structure of crystals were suggested to Hany by his observation that in a crystal, accidentally broken, the fracture showed regular geometrical faces.

(8) **Lastly, personal experience and individual reaction may give rise to hypotheses.** Some men seem to have a marked facility, a sort of instinctive judgement even in their guesses. To such people, the right solution (hypothesis) comes in a sudden flash of insight. This is true of many scientists. Einstein, for example, arrived at his general theory of relativity in this manner.

CONDITIONS OF A GOOD HYPOTHESIS

A hypothesis controls and directs scientific inquiry. Whenever a problem is felt, we require a hypothesis to explain it. Generally, there is more than one hypothesis which aims at explaining the same fact. But all these hypotheses cannot be equally good. Therefore, the question arises, "How can we judge a hypothesis to be true or false, good or bad?" Certain conditions can be laid down for distinguishing good hypotheses from bad ones. A hypothesis must satisfy these conditions to be accepted as good or valid. According to Jevons, "agreement with facts is the sole and sufficient test of a true hypothesis". The formal conditions laid down by thinkers provide the criteria for judging the usability of hypotheses. These conditions are as follows:

(1) **A hypothesis must be relevant:** The purpose of formulating a hypothesis is always to explain some facts. Therefore, the central function of a hypothesis is to explain those facts which generate the inquiry. And a hypothesis can explain the fact if it is relevant to the fact. The fact concerned must be deducible from the hypothesis as its logical consequence. Such a hypothesis is called a relevant hypothesis.

(2) **A hypothesis must be verifiable:** A hypothesis is said to be verifiable, if it can be shown to be either true or false. It must be possible to subject the hypothesis to the test of facts. A hypothesis is true if it conforms to facts. And it is false if it does not. A hypothesis should be empirically verifiable. Empirical verification is the characteristic of scientific method. That is, the hypothesis should have empirical referents. The concepts embodied in the hypothesis must have empirical correspondence. For instance, "eating too much of salt is a cause of high blood pressure" is a hypothesis that can be verified direct-

ly by subjecting some individuals to an empirical test. But if the hypothesis is based upon supernatural agencies such as God, ghost, angel, etc., it cannot be empirically verified because we have no knowledge of such beings. Galileo tested his hypothesis about freely falling bodies by dropping the bodies of unequal weights simultaneously from the Tower of Pisa. But the hypotheses about electrons, protons, etc. cannot be empirically verified.

(3) **A hypothesis must have predictive and explanatory power:** Explanatory power means that a good hypothesis, over and above the facts it proposes to explain, must also explain some other facts which are beyond its original scope. We must be able to deduce a wide range of observable facts which can be deduced from a hypothesis. The wider the range of observable facts which can be deduced from a hypothesis, the greater is its explanatory power. For example, Newton's hypothesis of universal gravitation had greater power than Kepler's hypothesis and Einstein's theory of relativity possesses greater explanatory power than Newton's hypothesis. The reason is that Einstein's theory not only implies the consequences of the former hypotheses, but has many more observable consequences besides. A hypothesis must lead to some universal principle which can be applied uniformly to all similar or allied phenomena.

(4) **A hypothesis must furnish a base for deductive inference of consequences:** In the process of investigation, we always pass from the known to the unknown. It is impossible to infer anything from the absolutely unknown. Jevons says: "We can only infer what would happen under supposed conditions by applying the knowledge of nature we possess to those conditions". Our hypothesis must be in accordance with our previous knowledge.

(5) **A hypothesis must be compatible with the established system of knowledge:** This condition lays down that, as far as possible, a new hypothesis should not go against any previously established law. Certain established laws already exist within the science and the new hypothesis, if accepted, would join them within a system of knowledge. Therefore, a new hypothesis is expected to be consistent with the established laws.

This does not, however, mean that a new hypothesis is to be abandoned merely because it conflicts with an established law. It is just possible that the new hypothesis may conflict with the established law and yet may be scientifically more correct. For example, the Copernican hypothesis conflicted with the then accepted Ptolemic hypothesis. Yet the Copernican hypothesis has been accepted as true, for it could more adequately explain the planetary motion. So, when the new hypothesis conflicts with the established theory and yet explains facts better, we should try to reinterpret and modify the theory and bring it into harmony with the new hypothesis.

(6) **A hypothesis should be simple:** A simpler hypothesis is to be preferred to a complex one. It sometimes happens that there are two or more hypotheses which explain a given fact equally well. Both of them are verified by observable facts. Both of them have a predictive power and both are consistent with established hypotheses. All the important conditions of hypothesis are thus satisfied by them. In such cases the simpler hypothesis is to be accepted. For example, according to Ptolemy, the earth is the centre of the universe and the heavenly bodies move around it. According to Copernicus, on the other hand, the sun is the centre of the universe and the heavenly bodies, including the earth, move around it. Both these hypotheses possess the characteristics of a sound hypothesis. Of the two, the Copernican hypothesis was accepted, for it was simpler. But of course, we must remember that the word 'simple' is a vague term. Simplicity is not familiarity. Therefore, the criterion of simplicity should be applied to hypotheses with care. One theory is simpler than another if it can, while the other cannot, show that the relations if established between things follow logically from the fundamental assumptions it makes. W. I. B. Beveridge in his book, **The Art of Scientific Investigation**, emphasizes that an investigator must take the following precautions in the use of hypothesis.

1. **Not to cling to ideas proved useless: We must take utmost precautions while using a hypothesis. Otherwise, it can cause trouble. We must be ready to reject or modify our hypothesis as soon as it is shown to be inconsistent with the facts. It is human weakness to observe only those facts and their fea-**

tures that support our theory and neglect or overlook those that go against our theory. There is the element of partiality It is not at all rare for investigators to stick to their discredited hypotheses, turning a blind eye to contrary evidence. If the experimental results or observations are definitely opposed to a hypothesis, one has to discard it. This points to the fact that we must resist the temptation to become too involved with our hypothesis. It was characteristic of Darwin and Bernard to reject or modify their hypotheses as soon as they ceased to be supported by the observed facts. Kepler advanced nineteen hypotheses which he later rejected and arrived, at last, at the true statement of the law of planetary motion. According to Whewell, "to try wrong guesses is, with most persons, the only way to hit upon the right ones".

On the other hand. faith in the hypothesis and perseverance is sometimes desirable. But we must note the difference between two types of situations. There is a great difference between (a) stubborn adherence to an idea which is not tenable in the face of contrary evidence and (b) persevering with a hypothesis which is very difficult to verify but against which there is no direct evidence. The investigator must judge the case with impartiality. He may adhere to his hypothesis against which there is no evidence, but he must discard his hypothesis which is inconsistent with the facts.

(2) **Ir ellectual discipline of subordinating ideas to facts:** An investigator is likely to be biased in favour of his own hypothesis. As soon as he formulates a hypothesis, parental affection tends to influence observations, interpretations and judgement. There is a tendency for a person to believe what he intends to believe. Glaude Bernard said, "Men who have excessive faith in their theories or ideas are not only ill-prepared for making discoveries, they also make poor observations".

The investigator should carry out observations and expe riments in such a way that they ensure objectivity. He should cultivate an intellectual habit of subordinating his beliefs and wishes to objective evidence. Thomas Huxley rightly observed: "My business is to teach my aspirations to conform themselves to fact, not to try to make facts harmonise with my aspirations. Sit down before fact as a little child, be prepared to give up

every preconceived notion, follow humbly wherever nature leads, or you will learn nothing."

(3) **Examining ideas critically:** An investigator should not be hasty in his decision of accepting a hypothesis as an adequate one. He must submit a hypothesis to a most careful scrutiny before accepting it even as a tentative hypothesis. He must bear in mind that once an opinion has been formed in favour of one hypothesis, it is difficult to think of alternative hypotheses. This is true of an idea that appears so 'obvious' that it is accepted almost without any question. For example, Farmers practised keeping the surface of the soil loose as a protective covering. They believed that this decreased the loss of water by evaporation. B. A. Keen showed that this belief was based upon inadequate experiments and that in most circumstances the practice was useless.

(4) **Shunning misconceptions:** A hypothesis may be fruitful even when wrong. Wrong hypotheses in course of time, give birth to right ones. But we must also remember the great majority of these wrong hypothses are abandoned as useless. Sometimes the wrong hypotheses, far from being productive, are actually responsible for holding up the advance of science, for example, the phlogiston doctrine. According to this doctrine, combustible substances contains a constituent called phlogiston, which is given up on burning. This notion for long held up the advance of chemistry. It was shown to be false by Lavoisier in 1778, but Priestley, a scientist, had not converted to the new outlook when he died in 1804. The point is that the investigator must abondon the misconceptions; only then can he march on to new discoveries.

KINDS OF HYPOTHESES

Hypotheses serve various purposes. It is the purpose of the hypothesis that determines its nature. On the basis of their purposes, Stebbing classifies hypotheses into explanatory, descriptive and analogical. Two other kinds of hypotheses are added to this list. They are ad hoc hypothesis and working hypothesis.

(1) **Explanatory Hypcthesis:** The purpose of this hypothesis is to explain a certain fact. All hypotheses are in a way expla-

natory, for a hypothesis is advanced only when we try to explain the observed fact.

A hypothesis which explains an individual fact or an event is called a hypothesis of cause or agent. A large number of hypotheses are advanced to explain the individual facts in life. A theft, a murder, an accident are the examples. A hypothesis that some other planet was responsible for the Uranus' deviation from its orbit also is of this kind.

A hypothesis which explains an individual fact in terms of a law is called a hypothesis of law. Here we already know the cause but want to know the manner in which it works. For example, we know the causes of the spread of diseases. But we want to know the operation of these causes.

When we arrive at a generalization within a particular field but its consequences are not directly observable, the generalization is sometimes called a transcendental hypothesis or a non-instantial hypothesis. A non-instantial hypothesis introduces order into generalizations and explains all the facts that fall within the scope of these generalizations. Newton's theory of gravitation and Einstein's theory of relativity are examples of non-instantial hypothesis.

(2) **Descriptive Hypothesis:** Sometimes a scientist comes across a complex phenomenon. He does not understand the relations among the observed facts. Now the questoin is, how will he account for these facts? The answer is a descriptive hypothesis. A hypothesis is descriptive when it is based upon the points of resemblance of something with which we are familiar. A descriptive hypothesis does not explain in a true sense, but expresses the causal connection by means of symbols. The Rutherford-Bohr hypothesis that the atom is constituted of electrons that revolve round a central proton just as the planets revolve round the sun and Freud's hypothesis that the unconscious mind is like an iceberg are the examples of descriptive hypothesis. Jevons observes, "There are hypotheses which we call descriptive hypotheses and which serve for little else than to furnish convenient names."

Stebbing says: "The essential characteristic of descriptive hypotheses is that they are not put forward as generalisations

from experience: they are not anticipations of natural laws awaiting confirmation. On the contrary, they are descriptions that serve the function of models enabling the scientist to understand the mode of connection between the facts for which he is trying to account. Such hypotheses must be regarded as essentially provisional or temporary."

(3) **Analogical Hypothesis:** When we formulate a hypothesis on the basis of similarities, the hypothesis is called an analogical hypothesis. Stebbing observes: "By an analogical hypothesis we mean a hypothesis that what is true of one set of phenomena may be true of another set owing to the fact that the two sets have in common certain formal properties. The law of gravitation is extended to electrical attraction on the ground of structural identity". Thus the basis of analogical hypothesis is properties common to two sets of facts. Since a descriptive hypothesis also depends upon the resemblances, it may sometimes develop into an analogical hypothesis.

(4) **Ad hoc Hypothesis:** An ad hoc hypothesis means a hypothesis which explains some facts after the fact has been established. On this interpretation the function of an ad hoc hypothesis is to explain the fact which cannot be explained by an accepted theory. The fact explained by an ad hoc hypothesis is the exception to the theory. An ad hoc hypothesis explains only that fact. It has no further explanatory power. For example, the law of gravitation was established, and it explained planetary motion. But a new problem arose. That is, Uranus deviated form its orbit. This problem could not be explained by gravitation. Therefore, scientists advanced the hypothesis that some other planet must be attracting Uranus. It was actually found that Neptune, another planet, was attracting Uranus.

(5) **Working Hypothesis:** Sometimes certain facts cannot be explained adequately by existing hypotheses, and no new hypothesis comes up. Thus the investigation is held up. In this situation, a scientist formulates a hyothesis which enables him to continue his investigation. Such a hypothesis, though inadequate and formulated for the purpose of further investigation only, is called a working hypothesis. This hypothesis does not claim to explain the facts. It is accepted simply as a starting point in the process of investigation. For example, when the

scientists could not understand the nature of electricity, they formulated a hypothesis that electricity resembles a fluid in facility and rapidity. Scientists knew that this hypothesis was inadequate, for a fluid adds to the weight of the medium through which it passes, but electricity does not.

A working hypothesis is only provisional. It is subject to revision, modification or even rejection in the light of further investigation. When a scientist hits upon a sound hypothesis, a working hypothesis is discarded.

VERIFICATION OF A HYPOTHESIS

When the hypothesis is framed, the next step in scientific investigation is its verification. Verifiability is one of the important conditions of a sound hypothesis. The hypothesis we have framed may be a good hypothesis, but we cannot accept it as true unless we subject it to the test of verification. A hypothesis must not remain forever a hypothesis. It must be either accepted or rejected. As Stebbing says, "A scientific theory that is incapable of experimental testing is valueless." Verification of a hypothesis consists in finding whether it agrees with facts of nature. If it agrees, it is said to be true and may be accepted as the explanation of the facts. But if it does not agree, it is said to be false. Such a false hypothesis is either totally rejected or modified. Verification is of two kinds: Direct verification and indirect verification.

1. **Direct Verification**: Direct verification of a hypothesis consists in actually observing the relevant facts which would justify the hypothesis. Here we confirm a hypothesis by actually observing facts. Direct verification may be either by observation or by experiment as the case may be. When direct observation shows that the supposed cause exists where it was thought to exist, we have a direct verification. As an example of direct verification by observation we may mention the discovery of the planet Neptune. The deviation of Uranus from its orbit was explained on the hypothesis that some unknown planet was attracting Uranus. On an observation with the help of telescope, Neptune was discovered. When a hypothesis is thus directly verified, it becomes a fact in nature.

When a hypothesis is verified by an experiment in a laboratory, it is called direct verification by experiment. As an ex-

ample of direct verification by experiment, we may mention the discovery of the gas argon. It was found that nitrogen from air was heavier than nitrogen from other sources. It was found on further experiment that the excess in the weight of nitrogen from air was due to the presence of one more gas namely argon. Thus argon was discovered. Of course, we must remember that very few hypotheses in science can be verified directly. This method would be applicable only to the non-scientific hypotheses of the common man.

(2) **Indirect Verification:** Some scientific hypotheses can be verified directly, but most others are incapable of direct verification. Therefore, a scientist has to depend upon indirect verification. Indirect verification is a process in which certain possible consequences are deducted from the hypothesis and they are then verified directly. Two steps are involved in indirect verification. The first step is that of deductive development of the hypothesis. By deductive development certain consequences are predicted. The second step is that of finding whether the predicted consequences follow. If the predicted consequences come true, the hypothesis is said to be indirectly verified. For example, Galileo formulated the hypothesis that the weight of the body is irrelevant to the speed with which the body falls to the ground. From this hypothesis the consequence was deduced that the heavier and the lighter bodies should reach the ground at the same time. Galileo conducted an experiment. He threw two cannon balls of different weights from the Tower of Pisa. The predicted consequences occurred. The cannon balls reached the ground at the same time. The hypothesis was verified. Similarly, the structure of atom cannot be directly verified. We deduce the logical consequences from the hypothesis and test them either by observation or by experiment.

PROOF OF HYPOTHESIS

The term 'proof' is not appropriate when it is used with reference to a hypothesis. Proof stands for certainty. To prove a hypothesis is to show that it is certain and it will never be refuted. A hypothesis is proved when there is no other hypothesis in the field. An established hypothesis must not only be adequate, relevant and verifiable. it must also be the only hypothesis to explain a particular fact. Thus the proof of a hypo-

thesis is not the same as its verification. It is something more than verification. Verification only confirms a hypothesis, simply because it does not eliminate all other relevant hypotheses. In other words, verification shows that C is the cause of E, but it does not show that C is the only cause of E. It shows that a hypothesis explains the observed fact well, but it does not show that this hypothesis alone explains the fact. Proof, on other hand, shows that this hypothesis alone and no other hypothesis explains the observed facts. C is the only cause of E. When a certain hypothesis is proved, the others are naturally rejected. But in this sense an investigator can never prove a hypothesis, because there is always the possibility of a new hypothesis in the light of advances of science. So, even if a hypothesis makes successful predictions and its consequences are verified, it is not proved beyond doubt.

According to W. I. B. Beveridge, "Generalizations can never be proved. They can be tested by seeing whether deductions made from them are in accord with experimental and observational facts. and if the results are not as predicted, the hypothesis or generalization may be disproved. But a favourable result does not prove the generalization, because the deduction made from it may be true, without its being true. Deductions, themselves correct, may be made from palpably absurd generalizations. For instance, the truth of the hypothesis that plague is due to evil spirits is not established by the correctness of the deduction that you can avoid the disease by keeping out of the reach of the evil spirit. In strict logic a generalization is never proved and remains on probation indefinitely, but if it survives all attempts at disproof it is accepted in practice, especially, if it fits a wider theoretical scheme".

When the results of the first experiment or observation do not support the hypothesis, we need not abandon it altogether. We may try to modify it. This process of modification may go on till the main hypothesis becomes over-burdened with ad hoc additions. The point at which this stage is reached is largely a matter of personal judgement. A hypothesis itself is a very personal matter. This fact is borne out by the observation that a scientist usually works much better when persuing his own hypothesis than that of some one else. It is the originator who

gets the personal satisfaction as well as the credit if his hypothesis is proved correct. A man working on a hypothesis which is not his own may abandon it after one or two unsuccessful trials, because he lacks the strong desire to confirm it. He should give a hypothesis a thorough trial and think out all possible ways of varying the conditions of the experiment.

The more appropriate word to use in this connection appears to be the word "confirm". Though a hypothesis cannot be proved, it can be confirmed. To confirm means to make firm or establish. Confirmed hypotheses are those that are empirically held to explain a particular set of facts at a particular time without necessarily being proved. Confirmation depends upon the empirical evidence in support of a hypothesis. Sometimes it is possible that several hypotheses that attempt to explain a phenomenon, stand verification. Thus, every one of them is probable. The process of confirmation consists in selecting out of several such verified hypotheses, that which is the most probable.

While establishing or confirming a hypothesis, a scientist takes into account the following:

(1) **The explanatory power of a hypothesis:** A hypothesis is formulated for explaining facts. But the explanation provided by one hypothesis may be more satisfactory than the explanation provided by another. One of the means of establishing a hypothesis is to show that it explains the facts better than its rival. Such a hypothesis is backed up by more empirical evidence. For example, the theory of evolution of the species is today received with greater confidence due to the amount and variety of evidence that supports it.

(2) **Predictive power:** The hypotheses are advanced to explain the facts. But from some hypotheses phenomena can be accurately predicted. Predictive power means that a hypothesis over and above explaining the facts that generated an inquiry, should also explain some other relevant facts. For example, Galileo's theory of acceleration enabled him not only to account for something he already knew, but also to predict something that was unknown to him. The theory predicted that if the acceleration of a freely falling body was constant, the path of a projectile fired from a gun inclined to the horizon would be

a parabola. Obviously, if a hypothesis is able to predict unknown consequences, it convinces us. We put more and more confidence in the hypothesis. The predictive power of a hypothesis convinces an investigator that the hypothesis is not merely the product of his imagination. It has its basis in facts.

(3) **The Crucial Instance:** Sometimes it so happens in science as in daily life, that two rival hypotheses are found to be equally adequate in explaining a phenomenon. Both of them satisfy the conditions of a good hypothesis. Both of them stand the test of verification. Now, both the hypotheses cannot be equally true. We have to find out which of the two rival hypotheses renders a better explanation of the phenomenon. In such a situation the scientist takes the help of an instance known as a crucial instance. The experiment conducted in such a situation is called Crucial Experiment. In this experiment a scientist has to find out the consequences which follows from one hypothesis, but is incompatible with the other. He conducts an experiment to find out whether or not this consequence occurs. The hypothesis that gives better explanation is accepted. The word crucial comes from the word crux. Crux means a finger-post which is placed at the cross-roads to point out the different roads. Thus a Crucial Experiment is conducted by a scientist to decide between the rival hypotheses. For Example: There is a glass jar containing some gas, and we are to determine whether it is Hydrogen or Oxygen. The gas is colourless, tasteless and without any smell. Both Hydrogen and Oxygen agree in possessing all these properties. So we have to make an experiment. We insert a glowing stick into the jar, and find that the gas begins to burn. This shows that the gas is inflammable. As we know that inflammability is the property to be found only in Hydrogen and not in Oxygen, we decide that the gas in the jar is Hydrogen and not Oxygen.

The Ptolemic hypotheis and the Copernican hypothesis were the two rival hypotheses about the planetary system. Both of them stood verification and hence both claimed to be true. The scientists, therefore, chose the phenomenon of the abarration of light as the crucial instance to decide between the two rival hypotheses. Copernican hypothesis alone could account for the phenomenon. Therefore, it was accepted as true and the Ptolemic hypothesis was rejected as false.

A crucial experiment may appear to be crucial only in the beginning while deciding the fate of two rival hypotheses. It is not crucial in the acceptance of one hypothesis and rejection of the other. However, we must remember that proof through crucial Instance does not establish a hypothesis as being true for all time. In the course of investigations. facts may come to light that may force the scientist to modify such a hypothesis. The facts may contribute the evidence in support of the rival hypothesis that was rejected.

FACT — HYPOTHESIS — THEORY — LAW

Fact and Hypothesis: Scientific investigation begins with facts and ends in facts. A scientist starts his investigation when a problem arises, and a problem arises when the observed facts are not intelligible. As possible answer to the problem, a scientist formulates a hypothesis. But a hypothesis is not the final answer of the problem. A scientist has to verify it. He verifies his hypothesis with facts. If the hypothesis agrees with facts. it is accepted. and if it does not agree with facts, it is rejected or modified. Thus, from beginning to end a scientific investigation depends upon facts. Since a scientific investigation depends so much upon facts, it is necessary to understand what the term 'fact' means. The 'fact' is used in different senses:

(1) The term 'fact' may mean the data presented in sense perception. In this sense, the colours we see, the sounds we hear, the odours we smell, the objects we touch constitute 'facts'.

(2) Secondly, the term 'fact' may mean an object or an event that exist in space and time independent of our reactions about it. Facts, in this sense, have an objective existence. They do not depend upon the subject perceiving them. They are neither real nor unreal. They simply are.

(3) Thirdly, the term 'fact' may mean our interpretation of the data given in sense perception. 'This is a mango', 'This present is precious', 'That man is kind-hearted' are 'facts' in this sense.

For science, facts are those statements or descriptions regarding objects and events about which there is an agreement among the scientists in the particular branch of knowledge.

There are various kinds of facts and their nature is determined by their uses in the various branches of science. There can be biological facts, psychological facts, sociological facts and so on.

Theory: When a hypothesis is confirmed by facts, it is called a theory. A theory indicates the hypothesis that is established. It refers to the general and the abstract as opposed to the factual, which is regarded as individual and concrete. Karl Popper writes, "Theories are nets cast to catch what we call 'the world', to rationalize, to explain and master it."

In earlier times, a theory was considered final and irrefutable explanation. But in modern times a theory is always held with some tentativeness, no matter how great is the empirical evidence in its support. It is considered to be the most probable or the most efficient way of accounting for facts.

Law: When a particular hypothesis is proved, it becomes a law. A hypothesis is proved when it is shown to be the only hypothesis in the field, that this hypothesis alone and no other hypothesis explains the fact under consideration. Thus, when a hypothesis is merely verified or confirmed, it is called a theory. But when it is proved beyond any doubt, it is called a law. Such a law is a universal statement whose scope is not limited to the observed instances: it can predict the nature of unobserved phenomena as well.

PLACE OF HYPOTHESIS IN SCIENCE

Hypothesis is a starting point of scientific investigation. Hypothesis aims at answering the questions 'How' and 'Why' of science. Hypothesis guides and directs the scientific investigation. Hypothesis unifies and systematises facts and attempts to explain them. Hypothesis makes all our observations meaningful and purposeful. In the absence of a hypothesis, we would not know what to observe and how to observe. Hypothesis enables us to understand the significance of facts in nature and prepares us to face them. Nature presents facts in a state of confusion. If observation is to detect the unity and order, it must not be a random perception, but a well-regulated observation, according to a definite purpose. And it is the hypothesis that guides and regulates our observation. The well-defined purpose of a hypo-

thesis is to indicate direction of the investigation and to suggest what facts are to be collected. Without hypothesis investigation becomes unfocussed and merely a pointless wandering. Prof. Northrop says, "The function of a hypothesis is to direct our search for order among facts, the suggestions formulated in any hypothesis may be solution to the problem. Whether they are, is the task of the enquiry." The hypothesis thus gives point of the inquiry. Without it the investigator may collect non-essential data and also overlook really significant ones.

Further, the verification of hypothesis requires the deductive development of hypothesis. New consequences are furnished. Many experiments are conducted to confirm the hypothesis. This procedure expands the range of significant facts, and thus widens the scientist's understanding of phenomena.

Further, every hypothesis aims at explaining a fact. But every hypothesis does not explain it. The hypothesis that does not explain the fact is ultimately discarded. But we must remember that even though a hypothesis is found to be false, it may be of great service in pointing out the way to a true hypothesis. Again, a hypothesis may be true or false, but if it is applicable to all the known facts, it serves as a means of binding those facts together. A false hypothesis also shows the direction in which further inquiries need not be made. Thus we find that a scientific investigation cannot dispense with a hypothesis. As Cohen and Nagel observe, "Hypotheses are required at every stage of an inquiry. It must not be forgotten that what are called general principles or laws can be applied to a present, still unterminated inquiry only with some risk. For they may not in fact be applicable. The general laws of any science function as hypotheses, which guide the inquiry in all its phases."

SUMMARY

Scientific thinking is problem-solving activity. A scientist collects facts through observation. But a scientist is not interested in merely collecting and describing facts. His aim is to explain them. When a scientist comes across a puzzling situation, he asks: "What can be the solution to this situation?" He formulates a tentative supposition as an answer to this situation. This tentative supposition is called a hypothesis. If such a hypothesis is not formulated, the scientist cannot go ahead with the investigation of his problem.

The Hypothetico-deductive method consists of four stages. They are (1) feeling of a problem, (2) formulation of a hypothesis, (3) deductive development of hypothesis, and (4) verification of hypothesis.

Hypotheses are suggested to an inquirer by something in the subject-matter under investigation and by his previous knowledge. No rules can be laid down for the formulation of a hypothesis. It is difficult to say anything about when a hypothesis will be suggested, how it will be suggested, and to whom it will be suggested. In general, the hypotheses are suggested in the following ways: (1) Imagination of a scientist; (2) Wide knowledge of the subject under consideration; (3) Analogy; (4) Simple enumeration; (5) Particular cultural environment; (6) When an existing theory or law fails to explain certain facts; (7) Accidental discoveries; and (8) Lastly, personal experience and individual reaction.

When a problem is felt and an explanation demanded, there are more than one hypothesis which aim at explaining the same fact. But all these hypotheses cannot be equally good. But how do we judge a hypothesis to be good or bad? Certain conditions are laid down for distinguishing a good hypothesis from a bad one. A hypothesis must satisfy these conditions in order to be accepted as a good hypothesis. These conditions are: (1) A hypothesis must be relevant. (2) A hypothesis must be verifiable. (3) A hypothesis must have predictive and explanatory power. (4) A hypothesis must furnish a base for deductive inference of consequences. (5) A hypothesis must be compatible with the established system of knowledge. (6) A hypothesis should be simple.

Precautions in the Use of Hypothesis: (1) Not to cling to ideas proved useless. (2) Intellectual discipline of subordinating ideas to facts. (3) Examining ideas critically. (4) Shunning misconceptions. We must take these precautions, otherwise a hypothesis can prove to be a dangerous tool.

A hypothesis we have framed may be a good hypothesis, but we cannot accept it unless we subject it to the test of verification. A hypothesis must not remain forever a hypothesis. It must be either accepted or rejected. Verification of a hypothesis consists in finding out whether it agrees with facts of nature. If it agrees with the fact, it is accepted as the explanation of the fact. But if it does not agree with the fact, it is either rejected or modified. In direct verification, the relevant facts which would justify the hypothesis are actually observed. Direct verification may be either by observation or by experiment. Indirect verification consists in deducing the consequences from the hypothesis, and testing those consequences by appeal to facts.

A hypothesis is said to be proved when it can be shown to be the only possible hypothesis which can explain the fact. Proof shows that this hypothesis alone and no other hypothesis explains the facts. In this sense, an investigator can never prove a hypothesis, because there always remains the possibility of a new hypothesis in the light of advance of science. Even if a hypothesis makes successful predictions and its con-

sequences are verified, it is not proved beyond doubt. While establishing a hypothesis, a scientist takes into account:

(1) The explanatory power of a hypothesis

(2) The predictive power of a hypothesis.

(3) A Crucial Instance.

A hypothesis is established, if it explains the problem more satisfactorily than its rival hypothesis. Such a hypothesis is backed up by more empirical evidence.

A hypothesis is established, if its predictive power is superior to that of its rival hypotheses. Predictive power means that a hypothesis, over and above explaining the facts that generated an inquiry, should also explain some other relevant facts. When a hypothesis is able to predict new phenomena, it gets further support. Prediction convinces the investigator that a hypothesis is not merely the product of his imagination; it has its roots in empirical evidence.

Sometimes two hypotheses are found to be equally adequate in explaining the facts. Both of them have support from facts. In this case, crucial experiment decides between the two rival hypotheses. A crucial experiment is the experiment the results of which are accounted for by one of the rival hypotheses. The hypothesis that accounts for those results is accepted, and the hypothesis that does not, is rejected.

A hypothesis starts with facts and ends in facts. Facts are those statements or descriptions regarding objects and events about which there is an agreement among the scientists. When a hypothesis is confirmed by verification, it becomes a theory. Theory is considered as the most probable or the most efficient way of accounting for facts. When a particular hypothesis is proved, it becomes a law. Thus, when a hypothesis is merely verified, or confirmed, it is called a theory. But when it is proved beyond any doubt, it is called a 'law'.

A hypothesis is indispensable to scientific investigation. From beginning to end, hypothesis guides and directs the scientific investigation. Without hypothesis a scientists would not know what to observe and how to observe. Without hypothesis an investigation becomes unfocussed and merely a pointless wandering.

In the deductive development of hypothesis, new consequences are furnished. Many experiments are conducted to confirm the hypothesis. This procedure widens the scientist's understanding of the phenomena. Even the false hypotheses are not useless. A false hypothesis sometimes points out the way to a true hypothesis. False hypothesis also shows the direction in which further inquiries need not be made. Thus, hypothesis is a very important tool in scientific investigation.

EXERCISES

1. What is a hypothesis? How are hypotheses suggested to a scientists?

2. State and explain the conditions of a good hypothesis.

3. Explain the general features of the Hypothetico-Deductive method?

4. Is scientific method synonymous with Hypothetico-Deductive Method? Justify your answer.

5. Distinguish between verification and proof of a hypothesis. Can a hypothesis ever be proved?

6. How is hypothesis related to fact, theory and law?

7. What is meant by verification? When is a hypothesis said to be established in science?

8. What is meant by verification of a hypothesis? Distinguish between direct and indirect verification.

9. . What is the role of hypothesis in scientific investigation?

10. Show how a scientist uses hypothetico-deductive method in his investigation?

Chapter Seven

SCIENTIFIC KNOWLEDGE

Complete phenomenalism — Fictionalism — Scepticism — Realism — Conclusion.

The purpose of this chapter is to discuss the theories of the nature and status of scientific knowledge. We shall consider the four epistemological theories concerning the problem of the nature and status of scientific knowledge. These theories are: (1) Complete Phenomenalism, (2) Fictionalism, (3) Scepticism and (4) Realism.

COMPLETE PHENOMENALISM

This theory is based on the principle that only observed phenomena have the status of knowledge. From this principle, it follows that science would concern itself only with the identification, classification and relation of phenomena. The Phenomenalists have put forward different theories because they hold different views regarding the nature of ultimate Phenomena. Broadly speaking, there are two kinds of phenomenlist theories. They are: (a) The phenomena are what we ordinarily perceive, and (b) the phenomena are analysed out of what we ordinarily perceive. However, they think that by confilining themselves to phenomena, it is possible to achieve certainty and gain permanent knowledge. Let us consider these theories, in detail.

(a) **The phenomena are what we ordinarily perceive:** The phenomenalism of Patricius was prompted and provoked by the confusion in astronomy towards the end of the sixteenth century. He believed that only what can be observed exists. There is, therefore, no distinction between what really happens and what seems to happen. Consequently there is no need of

hypotheses in astronomy. He believed that the planets are carrying out the commands of the Creator.

According to Berkeley, there is no distinction between real things and a person's perception of those things or the ideas about them in his mind. This belief enabled him to assert that all experience is of ideas. Only spirits can be causes of these ideas. Their cause is to be found in God's activity. In general, things in the world are God's perceptions and so great is his power that we, too, perceive. God has ideas in an orderly way. So science is the attempt to read God's mind, by discerning the orderly pattern of sequences of perceptions in our experience. The Laws of Nature simply describe the succession of phenomena. Science, therefore, must be confined to the identification of regular sequences of ideas. Both Patricius and Berkeley do not make any distinction between the things as they are and the things as they seem. They believe that the proper task of science is the formulation of the rules of succession of common experiences.

Sir Benjamin Brodie, Professor of Chemistry at Oxford, asked, "what were the characteristic chemical phenomena?" He found that they are operations by which the substances are prepared and the relative weights they have produced. Chemical reactions are really weight distribution changes brought about by chemical operations. His theory was later on rejected when the atomic hypothesis was advanced.

All three, Patricius, Berkeley and Brodie, share the view that scientific knowledge is about what can be perceived. Whatever cannot be perceived, cannot exist for science. The Laws of Nature and scientific theories are nothing but the records of past experiences. They can be used to anticipate future experiences.

(b) **The phenomena are analysed out of what we ordinarily perceive** : According to Mach, the Laws of Nature are summaries of what we have already experienced. The analysis of experience leads to the idea that its ultimate components are sensory elements. According to Mach, an apple consists of a group of sensory elements such as round shape, red and green colours in various patterns, firmness to the touch, sharply sweet to the taste, etc. These elements appear under different cate-

gories as they are differently related. So we cannot say that we have knowledge of things. We can rather say that we have knowledge of elements or knowledge of the order and sequence of our sensations. Sensations are the ultimate phenomena and knowledge of sensations the only true scientific knowledge.

According to Bridgman, science should be confined to those concepts which could be understood in terms of experimental operations, and then, whatever happened to theory, the content of true scientific knowledge would remain unchanged. Instead of conceiving of science as describing things and their properties, powers and interactions, it must be treated as describing the operations we perform in the laboratory and in the study. The operations of calculation, 'pencil and paper' operations, become the total empirical meaning of the theory. Science is concerned about such descriptions of operations, and they are the ultimate phenomena. Operationism of this kind was anticipated in spirit and in details by Brodie in his attempt at the reformation of chemistry. If the scientific knowledge consists of nothing but a set or sequence of operations, then it will exclude, for instance, the knowledge about the reasons why the operations are the way they are. Moreover, many operations produce entirely trivial and often pointless results.

A. S. Eddington, a great astronomer and mathematician, gives a still stranger conception of the ultimate phenomena. According to him, the numerical readings of the scales are fundamental phenomena. No doubt, the basic data are the numerical readings of instruments with scales. But what is the measure of the phenomena cannot by itself become the phenomena. His theory is based upon an unsound analogy between nerve impulses and brains on the one hand and stimuli around instruments and instruments being read by physicists on the other hand, as practically an identity. The instrument readings provide the data, like nerve impulses, and the physicist interprets them and constructs a world picture, like a person perceiving. This analogy is unsound because the brain is not aware of the nerve impulses in the way in which observers are aware of their data. The brain does not draw inferences about the world from the nerve impulses, nor does a person infer a world picture from his sensations. It is rather an instrumental theory

of perception than the perception theory of instruments, which is, in fact, needed.

FICTIONALISM

This theory of scientific knowledge states that theories are fictions. The theories are related to facts in the same way as novels are related to histories. According to this view, theories are the works of imagination and nothing else.

The fictionalist view is particularly common when there is some kind of crisis in science. When there are many theories and there is no way to resolve the issue, the concepts in the theories look like the characters in a novel. Ideal theoretical knowledge then becomes the best set of fictions. There are occasions in the history of science to indicate why some philosophers and scientists regarded theories as fictions. In the 16th century, there were rival theories in the field of astronomy put forward by Endoxus, Ptolemy, Tyclo Brake, Copernicus and Kepler. Each of these theories had passionate adherents, and when the conflict over the issues in Astronomy could not be resolved by further observation, the theories became competing fictions. Such episodes occurred in the field of chemistry and physics when there was a problem of the status of atomic theories in chemistry or when there was the problem of basic constituents of matter in physics, which in certain cases seemed to be like particle, and in others like waves.

The application of fictionalism in astronomy led the philosophers to general fictionalism: but the general method of science is the discovery of causes through an examination of these effects. The most comprehensive and the most convenient theory has the title to be representative of reality, unless it is shown positively that it is not.

SCEPTICISM

According to sceptics, there is no sense in asking which picture of the world is true. They leave the science in the same state as the fictionalists. But according to instrumentalism though the theories are neither true nor false, they are to be judged by whether they are successful or unsuccessful instruments for research. This view is called instrumentalism. This view is found in Gassendi's Theory of Sciences. He declares

that all hypothetical statements should be considered natural instruments, i.e. devices by which knowledge can be made more orderly and penetrating.

REALISM

Neither the phenomenalist, nor the fictionalist, nor the sceptical account seem at all plausible for the theory of virus in medical science. The virus theory does make sense because it seems to suggest that theoretical statements do sometimes refer to real things, whose existence is capable of demonstration. The word demonstration suggests the proof of existence which consists in pointing to things in the presence of the people. The realists distinguish between demonstration and reference. By reference, a thing is referred to, but it may be present or it may not be present. To show how theoretical statements refer to real things, the realists give three principles: (1) Some theoretical terms refer to hypothetical entities; (2) Some hypothetical entities are candidates for existence; (3) Some candidates for existence do exist.

For example, in the theories of disease we find in case of bacterium theory or virus theory, bacterium or virus were hypothetical entities in the initial stage. Their existence was proved by the invention of the microscope and electron microscope. The question of existence depends partly on the invention of instruments. In other words, there can be change from hypothetical entity to a candidate for existence and ultimately to real existence. So no concept can remain fixed in a definite epistemological status.

Conclusion: The four theories discussed above reveal the fact that both phenomenalism and realism have their place in the epistemology of science. Mechanics with its eliminable concept of force provides a model science for phenomenalists, the virus theory of disease provides a counter-model for realism. It seems, therefore, that science contains both kinds of theory. They are poles in the epistemology of science.

SUMMARY

There are four theories about the nature and status of scientific knowledge. They are: (1) Complete phenomenalism, (2) Fictionalism, (3) Scepticism, and (4) Realism.

According to complete phenomenalism, only observed phenomena have the status of knowledge. So the science is concerned with the identification, classification and relation of phenomena. Observed phenomena may be interpreted in two different ways: (1) the phenomena as we ordinarily perceive and (2) what is yielded after analysing. If we accept the first form of complete phenomenalism, then we cannot believe in hypothesis which go beyond the facts of observation. Whatever cannot be perceived cannot exist for science. The Laws of Nature and Scientific Theories are nothing but the records of past experiences. According to the second interpretation given by Mach, Laws of Nature are nothing but the summaries of what we have already experienced. The ultimate components of the phenomena are sensory elements. So we cannot have the knowledge of things, we can only have the knowledge of elements or sensations. Bridgman regards the operations that we perform in the laboratory and in the study as the ultimate phenomena. But operations may produce trivial and pointless results rather than scientific knowledge. Eddington gives a strange theory of the ultimate phenomena. According to him, numerical readings of the scales are fundamental phenomena. He regards the measure as the phenomena itself. But the measure cannot, by itself, become the phenomena.

According to Fictionalism the theories are fictions. This view is the outcome of crisis in science. When there are many theories and when there is no way to resolve the issue, they look like fiction and the concepts look like the characters in them. Fictionalism arose out of the confusion in Astronomy and then it gave rise to general fictionalism.

According to Sceptics, the theories are neither true nor false. They are either successful or unsuccessful instruments for research. This view is called instrumentalism.

These three theories may be called non-Realism. The non-realist theory cannot explain certain phenomena such as virus in medical science. According to realists, the existence of real things is capable of demonstration, if certain conditions are fulfilled.

Both phenomenalism and realism have their place in the epistemology of science.

EXERCISES

1. What is the nature and status of scientific knowledge according to phenomenalism?
2. What is realism? Can phenomenalism explain all phenomena?
3. Give explanatory notes on the following: (a) Fictionalism. (b) Scepticism. (c) Demonstration and Reference. (d) Operationalism.
4. Evaluate the theories of phenomenalism and realism.
5. Explain two different forms of phenomenalism.

Section II

SCIENCE, TECHNOLOGY AND DEVELOPMENT

Chapter Eight

SCIENCE, TECHNOLOGY AND SOCIETY

Science — Technique and technology — Technological progress — Impact of science and technology on society — Technological aspect — Cultural aspect — Philosophic and intellectual aspect

SCIENCE

Science serves two human purposes: to know and to do. The former is a matter of understanding, the latter is a matter of action. We may use the words 'Science' and 'Technology' to distinguish between these two purposes. But it must be noted that these two purposes go together. Science and Technology deal with the problem of acquiring knowledge of the working of Nature and producing tools for its control and utilization The difference between science and technology is: In science we investigate the reality that is given; in technology we create a reality according to our designs. Thus, science concerns itself with what is, technology with what is to be. The end of scientific activity is truth, but technology has a utilitarian goal. Technological ends are always empirical ends, the attainment of what is possible and demonstrable in this world.

Even before science could arise, different techniques were employed by man, in the past. Many techniques were used since prehistoric age but it is quite interesting to note that the term technology itself was first used by a German, Johann Beckmann, in 1772. Similarly, the word 'Scientist' was first employed by William Whewell in the early nineteenth century, although the people were in pursuit of scientific study for a long time. However, it would be wrong to suppose that the word 'technique' is equivalent to the word 'technology'.

TECHNIQUE & TECHNOLOGY

According to Jacques Ellul, "Technique is the totality of methods rationally arrived at end, having absolute efficiency (for a given stage of development) in every field of human activity." In other words, a technique or technical operation is carried out in accordance with a certain method in order to attain a particular end. Technology on the other hand pursues effectiveness in producing objects of a given kind. The general aim of all technical activity is efficiency. The structure of thinking leading to efficiency is different in different branches of technology. For example, the kind of efficiency aimed at by surveying is accuracy of measurement, while in civil engineering the decisive element is the durability of the construction. According to Skolimowski, "each technical activity has its own essential principle of efficiency and being the most instrumental principle of activity, this principle also serves as the yardstick of technological progress."

TECHNOLOGICAL PROGRESS

We can understand technology through the technological progress. Without the comprehension of technological progress, there is no comprehension of technology. The technological progress manifests itself through its ability to produce more and more different objects with more and more interesting features, in a more and more efficient way. It provides means for producing new and better objects of the same kind. By better objects we mean (i) more durable or (ii) more reliable or (iii) more sensitive or (iv) faster in performing its function or (v) combination of all the above factors.

In addition to these criteria, technological progress is achieved through shortening the time required for the production of a given object or through reducing the cost of production. It cannot be denied that contemporary highways and bridges mark a technological advancement in terms of durability when compared with Roman or even nineteenth century roads. Similarly, we can say that photographic cameras installed in artificial satellites are more sensitive than those used in the pre-Sputnik age. The jet airplanes are faster in speed than the planes of Wright brothers. If all these things

mentioned above can be manufactured less expensively or in shorter time, then it will equally mean a technological advancement or progress. By and large, when we think of technology, we think of machines, but it is wrong to think that technology means only machines. What it is, is decided by its problems, the existing tools and machines are just a few means.

All societies do not face the same set of technological problems. For example, uncivilised tribes are not faced with the problem involved in going to the moon or with the problems of coping with excessive traffic in cities. These are problems where highly developed technology has created its further technological problems. The scarcity of food and the growing population created the problems for technology. These problems were solved by producing the crops like high yield wheat, rice or cross-breeding and canned and frozen food etc. These are called technological developments exactly in the same sense when we call airplane as a technological development.

We must also bear in mind that not all technological progress is replacement and abandonment of previous means. For instance, the new problem of going to the moon was tackled with the old means of the rocket, similarly, new means are used to solve the old problems like flying at a greater speed. It is quite clear that the actions of men modify or reform nature, creating in it objects which had not existed before, either not at all or not where and when they were needed. The acts in their entirety constitute technology. Thus technology is the improvement brought about on nature by man for the satisfaction of his desires.

Technology is knowledge applied by man to improve production or marketing processes. It is reflected in tractors and corn pickers. It is embodied in hybrid seed corn, improved crop varieties, pesticides and commercial fertilizers. Technology is in the workshop, chemistry laboratory, field and office. Its objective is to provide greater output from a given amount of land, labour and capital resources. Technology is vital to the economizing process. As time passes, the fruits of technology — increased production at lower cost or better quality produced for the same cost — become cumulative. Not only

does the amount of technical knowledge increases, but its growth in all directions tends to grow at a continually faster rate.

IMPACT OF SCIENCE AND TECHNOLOGY ON SOCIETY

Scientific knowledge and its application in technology have revolutionised our whole way of life in this century. The impact of science and technology on civilized society has been profound and wide. The society is changing rapidly due to continued scientific and technological progress. The changes that have taken place during the 20th century are probably as great as all the changes recorded during the preceding thousand years. Consequently, men are more concerned about the future than ever before. The total all-pervading impact of science which has brought about tremendous changes in the structure of human society has also raised grave social, political and economic problems in all industrial societies. The rapid changes have created tensions of all kinds: social, psychological, political and economic. These tensions tend to all kinds of problems. It is, therefore, necessary to study these problems and to avoid the serious tensions and imbalances that western societies have passed and are still passing through. All these problems have been discussed, in detail, in the relevant topics in this book. However, we shall take a cursory view of the impact of science on society. For the sake of convenience we shall consider the three aspects of the impact, viz. (i) Technological, (ii) Cultural and (iii) Philosophical and Intellectual. Readers should go through the other topics for details of these impacts.

TECHNOLOGICAL ASPECT

Technology is the link between science and society. By observing the various uses of matter and energy, a layman understands that science has advanced but he fails to distinguish between the advancement of technology and advancement of science. What a layman observes is, really speaking, the technological advancement. Technological impact on society is rapid and perceptible. J. D. Bernal rightly says, "Science reacts on society unconsciously and indirectly through the technical changes it brings about . . . ."

Man has been able to control his material environment by the use of tools and application of reason to the properties of matter and energy. But this is not an easy task. The modern development has taken place due to the efforts of different scientists and technologists for a number of years. The progress was made by trial and error method. For example, upto the 18th century, technology has been based upon craft skills, patience, much labour and remarkable ingenuity. We may call the societies of the 18th century as "Craft" societies. Since the 18th century, technology has developed the use of machines, power and precision. It created a new way of life. The society in which such technology was developed is called industrial society. Highly sophisticated technology used in day-to-day life has created the society to which Daniel Bell, the sociologists gives the name 'Post Industrial Society'. It is so-called because industrialization is fully developed in such a society and has created the peculiar problems faced by post-industrial society are entirely different and hence while evaluating technological impact we will have to consider socio-economic as well as cultural-religious background of the society. It is important to note that there has always been a close interaction between the form of man's society and the technology which it produces. The political, social economic and even religious organization of a culture influences the kind of problems and goals that are set before the technologist. This is one of the reasons for non-implementation of certain projects in the underdeveloped countries although the countries have all the technical know-how of such projects. To elucidate this point, we shall consider the changes which have been taking place in the agricultural production process.

Technological progress has allowed the food production potential in the western world to outpace population growth. The technological change has altered the structure of the agriculture production process. The reaper, the seed drill, the steel plough and the threshing machine made farming possible on an extensive scale. The steel plough was perfected by John Deere in 1840. It evolved from the wood and cast-iron ploughs Corn planters and wheat drills greatly simplified the planting process and the reaper mechanically harvested grain that for centuries had been cut with a hand sickle. After 1910, the

introduction of tractor revolutionised farming. Further, the substitution of rubber tyres for steel wheels decreased fuel consumption and extended the life of the tractor.

Plant technologists have succeeded in breeding new varieties of plants to withstand drought and diseases. They have succeeded in developing higher-yielding varieties. Hybrid plants continue to bring new revolutionary developments in the forests, fields and gardens. The use of fertilisers gained impetus after World War I, slowed down during the depression and has risen continuously since 1937. Fertilizer has tremendously increased yields.

The canning of fruit, vegetables and fruit juice was an important technology in preserving foods. Similarly, freezing technique was developed. Freezing techniques avoid deterioration and keeps the products fresher. Freezing and canning techniques have made possible the import and export of food. These techniques have brought the different countries nearer.

Technological change always has an effect on the level of agricultural price. As new technology is introduced and per unit cost of production declines, the quantity and quality of input increases. Thus, the application of new technological advancements generally results in lower cost of production, expanded output and lower prices. But the technological improvement was followed by certain evil practices in society. The institution of slavery was introduced with the motive of making more and more profit. The stronger people captured the land and forced the weaker people to work as slaves. The economic nature of modern capitalism is historically bound up with the development of technology. The dynamics of capitalist economy is bound up intimately with modern technology. In the under developed countries, it is not possible to bring into practice the modern methods of agriculture, due to the political, social, economic and religious conditions, and hence there is no high yield of crops. Moreover, due to the population growth, there is scarcity of food which in turn upsets the entire economy of the under developed countries.

Technological impact on agriculture is just one example and there are number of other spheres of life in which technology has played major role. For example, the population

explosion is a direct product of medical technology, the urban chaos is the outcome of transportation technology, the disruption of ecology is due to the use of pesticides, fungicides and it is also due to the outcome of waste products of many technologies In the future, some of these accumulated consequences will become more emphatic and complex, when the new technologies contribute their consequences, too.

CULTURAL ASPECT

The terms culture and civilization are used in a variety of senses. The differences in the use of these terms are due to the general misunderstanding as to the nature and meaning of human achievements. These terms should be used as technical terms for ordering and rendering intelligible the complex phenomena of human life and experiences. Valuation is a central fact in human experiences and activities. So we should consider culture as a value. Man, indeed, seldom concerns himself with mere facts. He contemplates factual realities under the evaluative categories of ('ends' and 'means'). Even the most disinterested questions and queries with which science is concerned are connected with one human interest or the other and all that interests man is to him valuable. So, normative study of culture cannot be kept rigidly apart from a factual study thereof. The advancement of man lies in the expansion and progressive refinement of his cultural consciousness. In other words, it should be directed towards expansion and refinement of the human personality, i.e. towards the re-establishment of the primacy of the (creative) person and not towards unlimited and unscrupulous acquisition of wealth and power. In the light of this direction we have to consider the impact of science and technology on culture of society.

Modern community has come nearer than ever due to the development of communication systems and it shares all the achievements of mankind from the different corners of the world. Modern community depends on science for its very existence. Modern community has at its core the economic values rather than spiritual values, due to industrialization. The pursuit of economic growth and improvement in the material conditions of life are treated as the 'master values of modern societies. The core institutions of an industrial

society are centred around the above objectives and religious institutions at the periphery. It has only one value, the value of technology, organization, efficiency, growth, progress, only such single value-mindedness would turn man into a machine. The instrumental rational action of the modern man handicaps him from being a substantively rational. It may fail to satisfy other important human values and purposes.

There are certain signs of a growing challenge to routinization including attempts to break away from rigid stylised techniques in the arts, the music, painting and sculpture and move towards more flexible, participative styles in administration and management. The modern technology has brought the arts into intimate relationship with the society. The art that was first of all influenced by technology, in the industrial age was architecture. The industrialization which by itself was unplanned, gave rise to unplanned cities. The styles and designs of structure lacked a plan or purpose. A functional philosophy of construction came from engineering. To-day there is a trend towards synthesis and cross-fertilization in all fields of knowledge.

There is a spirit of calculation in capitalist economy. The spirit is reflected back in all aspects of life. Numerous novel media of mass communication and entertainment have facilitated wide and rapid diffusion of culture, compared with biological evolution of species, cultural and social evolution is extremely rapid due to mass media of communication. However, each culture has its own characteristic pace—sometimes different sectors within the same society exhibit different rates of change. This disparity is called cultural lag. So, there is gradual alienation from and breakdown of earlier more stable system of value and faith. The strong traditional beliefs, orthodoxy and accepted codes of values are being demolished, by science.

PHILOSOPHICAL AND INTELLECTUAL ASPECTS

Philosophy is the study of the nature of man's understanding of reality. The proper task of philosophy is to think rationally, to circumscribe the efficacy of reason and to make us feel it in examples. The scientists who brought new facts. called for a "new way of thinking." The intellectual knowledge

or the knowledge of what exists has its impact on reason and in understanding reality. From this point of view we shall consider the impact of science and technology on society in its philosophical and intellectual aspect.

Let us begin from the primitive man. Thinking of primitive man was dominated by magic and superstition. He had a curiosity but he was ignorant of the mystery of Nature and he was dominated by the religious sentiments. The development of science has freed man from the ignorance and superstition. The concepts of heaven and hell, spirits and souls, gods and Supreme Being, and the mysterious astronomical phenomena such as eclipses, comets, and stars made the primitive man to look at everything from the point of view of religion. The work of Copernicus, Galileo and Newton and findings of modern scientists explain the universe of planetary system and the deeper reality of the infinite universe. Observation which is the first stage of empirical and rational work was viewed as irreligious and the scientists had to suffer a lot for 'observing' In the beginning, there were clashes with tradition, and traditional or religious authority. However, the world view of religion changed gradually. The credit goes to the scientists who dared to speak plainly about the new fact. What scientists said is almost always purposive and intellectual and in line with scientific thinking, although today their thoughts may not be the scientific truths.

What Galileo and Newton did for astronomy, Darwin did for biology. His idea of struggle for existence removed the purpose of the Supreme Being. Instead of supporting the religious theory that the existence of man has divine source or a creator, Darwin lineked man with other creatures Similarly, his idea of the natural selection or the survival of the fittest, snatched the 'soul' of the religion. There was a blow to the deterministic trend in creation. Darwin's view is that creation is not static but changing in time. The modern biology goes still beyond and points out that man shares a body chemistry (i.e. number of amino acids) with all other creatures. So, origin of man and life in general has now natural or scientific explanation and not the divine one.

Darwin's theory had another great influence. It shaped the contemporary psychology. Study of genetics led to the study

of individual differences in psychology, observation and experimentation helped the growth of psychology into a number of branches. Psycho-analysis, which is a school of psychology, had tremendous intellectual impact. The analysis of dreams, unconsciousness, and the theory of 'censorship' maintaining the unconscious in its unconscious state, explained many things concerning the human beings. The technique of hypnosis was also used. The fundamental principles of Freud's psychoanalysis is the dynamic nature of the unconscious. It revolutionized ethical system and religious beliefs and provided a new insight into the foundations of social and political system. Freud's thought had influence over the different areas of life. He gave a profound death-blow to religion when he showed it to be an activity of compensation. According to him, religion arises from the child's feelings of helplessness in a hostile world and from the longing for a guiding and protecting father. The divine status of religion and morality was lost in psychoanalysis. Similarly, distrust of authority is the result of psychoanalysis. According to Freud, authority, is nothing but the wish to exercise power over others which is sublimated in a variety of ways. This view also gave rise to a general distrust of authority in the modern world.

The notion of self-expression in art is also partly a result of psychoanalysis. The discovery of electron in 1897, led to the notion that there is underlying structure, a world within the world of atoms, captured the imagination of artists. Modern art begins at the same time as modern physics because it begins in the same ideas. In short, the rationalist tendency of the modern times has helped to dissolve the mystical element in the consciousness of man. It reflects the decline in the force of religious values.

Struggle between science and religion was the central conflict of the intellectual world in the past. A scientist was practically synonymous with an atheist or at least an agnostic This struggle has been now resolved by discovering that there is nothing incompatible between the two. The eminent scientists view with bishops in supporting mystical views of the universe and of human life. In the 19th century religion was really trying to interfere with the growing sciences of biology and geology. The 20th century has brought advances in many

fields of science and the break-up of many interpretations that had been taken for granted earlier. The modern science has become a complex source of new ideas and concepts.

SUMMARY

The purpose of science and technology are different but science and technology go together. In science we investigate the reality that is given whereas in technology we create a reality according to our designs. The goal of science is truth but technology has utilitarian goal.

Technique is the method of attaining a particular goal and in general its aim is to attain efficiency. Technology, on the other hand pursues effectiveness in producing the objects of a given kind. The structure of efficiency is different in different technologies.

We can understand technology through the technological progress. The technological progress manifests itself through its ability to produce more and more different objects with more and more interesting features, in more and efficient ways. Different means are used for producing new and better objects of the same kind.

Technology does not mean machines. What is it, is decided by its problems.

Scientific knowledge and its application in technology have revolutionised our whole way of life in this century. It has created many problems such as social, political, psychological and economic. We shall consider the impact of science and technology in three aspects, namely, (1) technological aspect, (2) cultural aspect, and (3) philosopical-intellectual aspect.

Technologically, man has been able to control his material environment. Technology changed the craft society into industrial society and post-industrial society. The problems of each society are different. To find out the technological impact, we will have to consider socio-economic as well as cultural — religious background of society. Technology used in underdeveloped countries and their problems differ from the technology used by developed countries. Agricultural production process has changed radically, but in underdeveloped countries, is not possible. There are many other technologies which have both the good and adverse effect on society.

As regards cultural aspect of society is concerned, science and technology have made man to think in terms of economic values. Man has forgotten that culture is a value and it is not to be equated only with the material achievements. There are certain advantages of technology such as new mass media of communication which have facilitated wide and rapid diffusion of culture. There may be cultural lag in some societies. Gradually, there is breakdown of stable system of values because strong traditional beliefs, orthodoxy and accepted codes of values are being demolished by science.

Philosophical and intellectual aspects of society have been greatly influenced by technology. Since, the time of primitive man, the understanding of reality has changed. The first major change is in the religious ideas. Astronomy, physics, biology, chemistry, psychology have changed and they have changed the entire society. Science and religion was the central conflict of the intellectual world in the process of the development of science, and technology. Science is the complex source of new ideas.

EXERCISES

1. Distinguish between: (i) Science and Technology. (ii) Technique and Technology.

2. What are the criteria of technological progress?

3. How do the technological problems arise? Give an example.

4. Why is man in the industrial society more concerned with the future?

5. Discuss the nature of the impact of science on any one of the following aspects: (i) Technological, (ii) Cultural, and (iii) Philosophical and Intellectual.

Chapter Nine

HEALTH

Health — Public health — Bio-medical science and health — Bio-engineering and health — Environmental pollution and health — Health education and productivity

Science is an instrument of great philosophic and social significance. It is both an end in itself as a search for truth and also a means of promoting human happiness. An unhealthy man cannot be happy even if he gets all the benefits of science and technology. So, health is an important issue in the modern times. It is followed by the problems of productivity and communication as they have direct bearing on man's health. In this chapter we shall consider how science is being applied to the improvements in the fields of health. It is quite natural to expect that the results of scientific investigation should lead to continuous progressive improvements in conditions of life. The conditions of life are improved by scientists and technologists only when they correlate their work with the social and economic developments of the society in which they live. Let us consider in detail how this is being done in the fields of health, productivity and communication.

HEALTH

The definition of the concept of health would give us some ideas through which we can get a picture of the evolution and progress in that field. For centuries health was defined as a condition of the human body devoid of disease or injury. It is obvious from this definition that all people do not have the same health. Some people are more healthy or less healthy than others. We may even say that an individual is more healthy at one time than at another. The World Health Organisation in its constitution has stated that health is a state of com-

plete physical, mental and social well-being and not merely the absence of disease or infirmity. This is a statement of aims and principles rather than the definition of health. The work 'complete' in the above statement is vague. There is no single quantitative measure which can be used to determine the completeness of the well being of all sorts of people. It is now clear that when we consider the role of science and technology in the improvements of health, we are not concerned with an individual's health but with the public health.

PUBLIC HEALTH

Public health is dedicated to the common attainment of the highest level of physical, mental and social well-being and longevity, consistent with available knowledge and resources at a given time and space. It contributes to the total development of life of the individual and his society. Public health may be defined as the art and science of maintaining, protecting and improving health of the people through organized community efforts. Winslow's definition of public health would be useful to enlist the various problems with which public health is concerned. According to Winslow, public health is the science and art of:

(i) Preventing diseases;

(ii) Prolonging life; and

(iii) Promoting health and efficiency through organized community effort for:

(a) the sanitation of the environment;

(b) the control of communicable infections;

(c) the education of the individual in personal hygiene;

(d) the organization of medical and nursing services for the early diagnosis and preventive treatment of disease; and

(e) the development of the social machinery to insure everyone a standard of living adequate for the maintenance of health.

From the above analysis it is obvious that public health includes almost everything in the field of social service and

reform. It also provides the sequence of the historic development of public health as well as present day and probable future trend. Early definitions limited public health essentially to sanitary measures and invoked against nuisances and health hazards. Following the great bacteriologic and immunologic discovery of the 19th and early 20th centuries and subsequent techniques for their application, the concept of prevention of disease in the individual was added. Public health then came to be regarded as an integration of sanitary science and medical science. Although man is born with some genetic characteristics his environments play a great role in developing both the body and the mind. The interaction between man and his environment is the first and basic stage in preventive medicine. The prevention of diseases is possible through such improvements in environments as better housing, a pure water supply and the thorough removal of refuse and sewage, etc. The aim of all such measures is to eliminate obvious harmful influences. For example, refuse is a breeding ground or food source for rats, flies and other potential carriers of disease of man. It is the cause of foot and mouth diseases or cholera. Particulate matter and smoke from the burning of refuse can be a significant source of atmospheric pollution and improper refuse disposal may result in surface and ground-water pollution. So, sanitary refuse disposal is essential to community health. Matters of first concern in environmental health, such as sewage and refuse disposal, are usually dealt with by the civil engineers of local authorities, likewise, the heating, lighting and ventilation of buildings; features which are all of prime importance for health, are handled by architects. The next step is to protect the individual himself, beginning with help and advice on his upbringing as a child, especially in respect of nutrition, protecting him by inoculation against the infectious diseases to which he may be exposed, and watching over his growth and development so that any abnormality or defect which appears, can be promptly dealt with. Yet, preventive medicine has developed into something even more positive; it may be in pursuit of positive health, which goes far beyond mere elimination of illness. Only a part of preventive medicine can come within the direct purview of doctors; they advise, but much of their advice is left to others to carry out. Parents

may receive guidance from doctors or nurses, but the upbringing of their children is of course in their own hands.

THE BIO-MEDICAL SCIENCE AND HEALTH

Medicine has changed more in the last forty years than in previous four hundred years. The following facts would throw light on the impact of the revolution in bio-medical science on society. The widespread employment of vaccination against small-pox after 1800 was a specific contribution of medicine. Similarly, cholera was brought under fairly effective control by hygienic measures even before the germ theory of infectious disease was formulated by Pasteur in the 1860s. Ehrlich was the father of chemotherapy and the first worker deliberately to use the methods of scientific biochemistry to devise methods of killing the causal agent of the disease called syphillis without deleterious effect on the patients' tissues. The development of sulphonamide drugs in the 1930s removed the fear and horror of bacterial sepsis from childbirth, severe physical injury and surgical operation. The pneumococcal pneumonia could be cured within a few days by a handful of tablets. Prior to these developments, medical treatment had been largely symptomatic. Opium, quinine, digitalis had been known for many years, but all the innovations came from the chemical industry, together with techniques for purifying and standardising drugs and for establishing methods of measuring their activity and efficacy. Aspirin had been introduced in 1899 and it remains the most effective of the minor analgyestics as well as the best and safest anti-rheumatic remedy. Phenobarbitone is still the most widely used drug in the treatment of epilepsy. The extensive range of barbiturate drugs are invaluable in the treatment of sleeplessness, anxiety and agitation. However, these drugs are for the control of symptoms rather than the treatment of causes. Introduction of septrin (Bactrim) in 1968, for a broad range of bacterial diseases was a major contribution. The production of penicillin early in the second world war opened up a new era and streptomycin, tetracycline and the more sophistical and modern antibiotics have virtually completed the conquest not only of bacterial infection but also of spirochaetal diseases including syphillis.

The triumphs of clinical virology (the conquest of poliomyelitis) have been prophylactic and preventive rather than therapeutic. There is effective protection against measles, rubella (german measles) and mumps.

Modern surgery is possible only because of modern anaethesia which renders prolonged and complicated operations both safer for the patient and less difficult for the surgeon. The intensive care renders valuable service in survival of many cases of prolonged unconsciousness such as due to poisoning and in tetanus.

The disease of chronic renal failure was fatal fifteen years ago. The artificial kidney which filters out toxic impurities from the patient's blood by dialysis was originally introduced for the treatment of acute reversible renal failure, such as that induced by surgical shock or poisoning causing damage to the tubules of the kidney. Here, dialysis often sustains life until spontaneous recovery ensures.

The development of psychopharmacology has been even more remarkable. Its benefits are reflected in the increased happiness and social effectiveness of a very large number of patients. For several depressed patients monoamine oxidase inhibitors (MAO drugs) are used successfully. Even these drugs are replaced by the tricyclic antidepressants of the imipramine group which in turn have been modified and improved. This is probably the most important development in medical treatment since the discovery of penicillin.

BIO-ENGINEERING AND HEALTH

The bio-engineering industries are making attempts to replace the medicinal treatment. It is believed that by 1984, it would be possible to replace tissues and organs. For example, already many cardiac patients are alive due to the invention of 'pacemaker' — a tiny device that sends pulses of electricity to activate heart. Similarly, hearing aids, artificial kidneys, arteries, eye sockets, are already in various stages of development in the bio-engineering industries. The bio-engineering industries may reorganize the entire health system: they may change life expectancy and make surgery and implantation a routine job.

ENVIRONMENTAL POLLUTION AND HEALTH

Environmental pollution has been defined as an unfavourable alteration of the environment from the effects of changes in energy patterns, radiation levels, chemical and physical constitution or abundances of organisms. Its study is important because it challenges the survival of human beings. Today environmental disruption has become a global problem. The first United National Conference on the Human Environment was convened in Stockholm, Sweden in June 1972. Its purpose was to alert government and their peoples to the damage which man's activities can bring to the natural environment—damage which creates serious risks for the survival and well-being of man himself. Environmental pollution caused by industrialization, urbanization and modern agricultural practices is a serious probelm in the world. We will consider some of the problems of pollution which are concerned with satisfying our basic needs as food, water and air.

Food: Human body is often compared with a chemical factory. It has ability to take nutrition from the plants and animals we eat, the water we drink and the air we breathe. The food we eat is converted into the marrow of our bones, the tissue of our flesh and the substance of our bodies. If the food fails to supply us the nutrients our bodies cannot grow or remain strong. When the nutritional needs are not satisfied, our mental abilities are affected. For example, a shortage of the Vitamin B Complex may make learning more difficult or by taking Vitamin E our memory may improve. It must also be noted that the satisfaction of the desire for food accompanied by generosity and love can lay the foundations of a child's emotional health and stability.

There is no need to stress the importance of food for both body and mind. However, it is important to study that if our food contains poisons, it can destroy the ability of the body's chemical factory to function properly. By accident, if the pesticides get mixed up with the food, it can be cause poisoning and death. Sometimes the food is poisoned by traders to cheat the customers. For example, fish can be deliberately treated with a chemical preservative called sodium nitrate to hide the fact that the fish has become stale and smelly. Eating such

fish may cause serious illness and death. A poison called Ergot which is the toxic product of a fungus grows on rye and other grains. If such foodgrains are used, they may lead to gangrenousblackening of the limbs or convulsions.

Wastes from the food processing industry — meat and dairy products, beet sugar refining, brewing and distilling, canning etc., tend to be troublesome because the waste containing high percentage of decomposable organic matter can lead to oxygen depletion and water supply impairment. Typhoid, hepatitis and dysentery are well known diseases carried by pol luted water.

Water: Water is the major element of all our food and drinks. Water supplies can become polluted in many ways — by water collecting in soil picking up pollutants and by public water supplies being drawn from polluted rivers, lakes and wells. When the sewage is dumped into rivers and lakes, the threat exists that disease carrying bacteria may be polluting our water supplies. Some of these bacteria are capable of causing typhoid, fever, dysentry, cholera and gastro enteritis or the mild illness such as nausea, vomiting and diarrhoea. Water purification plants are able to remove many of the impurities from human and animal sewage with chemical treatment and careful filtering. But, as the pollutants become more numerous complex and toxic, the water treatment plants cannot remove them all. For example, pesticides, weed-killers and chemical fertilizers are proving to be an even greater threat to our water supplies than sewage. Some of the agricultural chemicals remain active in the environment for a very long time because they do not easily break down into natural organic materials. The insecticide DDT seems to last almost indefinitely. DDT accumulates in the living tissues of plants, insects, birds, fish and other animals. If each living organism feeds upon another, the amount of accumulation of DDT increases considerably. The man who is at the top of the food chain is ultimately affected due to concentration of DDT in his food. It is not yet known how the concentration of DDT harms the human body, but it is well known that DDT causes sterility and cancer in fish, birds, and other animals. Water-treatment plants are so far unable to remove DDT from public water supplies.

Arsenic is one of the ingredients in some pesticides and detergents which is poisonous for living bodies. A very few highly sophisticated sewage treatment plants can remove it. It goes into waterways as part of the waste from some industrial plants. Nitrate fertilizers are also dangerous. The bacteria that live in the intestinal tract can convert it into highly toxic nitrite which causes serious illnesses and even deaths. The farm wells are likely to have nitrite concentration.

Radiation is another danger in public water supplies. It comes from the fall-out from nuclear explosions and from accumulation of low-level radio-active wastes which are discharged into the environment from nuclear power plants and from nuclear industry. The radio active elements such as strontium damages bone marrow or cesium affects the muscles.

Lead is another serious pollutant in water. Small amounts of lead poisoning may cause loss of appetite and weight, fatigue, headaches and slight anemia. Severe lead poisoning results in pains, irritability and lack of coordination and finally permanent brain damage and death. The major source of lead pollution is industry.

Mercury is another pollutant which affects fish and when fish containing high levels of mercury is eaten continuously, it can cause poisoning and brain damage in human beings. The major source of mercury pollution is the wastes of industrial plants. Mercury also comes from the chimney stacks and vents of power plants, factories and heating systems which burn bituminous coal and crude petroleum. Mercury in the form of inorganic compounds is converted into highly poisonous organic compound methyl mercury by certain methylating bacteria which exist in the soil and sediments of river. Traces of mercury occur naturally in the ocean by the erosion of mercury bearing rocks.

It is essential to prevent polluters from discharging into the environment mercury and other harmful metals and chemicals which can accumulate into dangerous amounts in water we drink and the food we eat. It is difficult to kill all the germs in water even by using modern water purification systems. In some countries water is not filtered, it is at the most chlorinated. Chlorination of water is useful because it stops tooth-decay

to some extent, but excess of chlorination is harmful. Moreover, chlorination does not kill all the germs.

Water treatment: It is the application of physical and chemical processes to water supply to remove tastes, odors, dirt and debris, to reduce "hard" elements and salts, and to destroy harmful organisms. Debris removal, required for surface-water supplies, is accomplished by adding coagulation chemicals, e.g. aluminium sulfate (alum) or iron sulfate and lime in a mixing chamber. Coagulation is effected by slow and thorough mechanical agitation for about ½ hour, during which coagulant particles about snow flakes size are formed; these are aluminium or iron hydrooxides. Particles of dirt and organic debris (turbidity and colour) adhere to the coagulant. Sedimentation then takes place for several hours, clarifying the water of debris and coagulant particles. For a sparkling water, sand filtration follows. Additives also are used. Chlorine is added as a disinfectant to all municipal water supplies to protect against enteric diseases such as typhoid fever. Chlorination usually takes place before water pumped into the distribution system; it follows filteration or open reservoir storage.

Air: Lead, fluorides, radio-active particles, pesticides, etc. are the pollutants thrown up into the air and fall into the water we drink, and the soil in which our food is grown. For instance, in 1957, in the north of England, an accident at a nuclear reactor released large amounts of radio-active materials into the atmosphere. Two hundred square miles of surrounding farmland were seriously contaminated by the nuclear fall out. When the cattle grazed on the grass land, they consumed large amounts of radio-active iodine. It is a dangerous substance because it can cause cancer of the thyroid gland in human beings. There is also a risk of passing genetic abnormalities on to their children. Following is a brief survey of the general and specific air pollutants and their most probable sources.

Among the general air pollutants we may include sulphur dioxide, particulates, oxides of nitrogen, carbon monoxide etc. There are different sources for the different pollutants. Some of the common sources are: domestic fires, brick works, coke ovens, electricity generation and steel works, vehicle emissions, cement works, ceramic manufactures, nitric acid plants, ferti-

lizer plants, etc. Among the specific pollutants we may include ammonia, bromides, chlorinated hydrocarbons, chlorine and hydrogen chloride, flurine and fluorides. The various sources of these pollutants are: ammonia works, motor vehicle emissions, dry cleaning establishments, chlorine works, aluminium works, brick works, glass works, etc.

Technologically, the methods of evaluating and controlling air pollution at global levels are available. We need not go into their details. Although there is a danger of a variety of environmental pollution from the different sources, the optimists feel that our civilization will survive if man is awakened to the dangers and adopted to technology. The pessimists, however, think that the end of our civilization is so close that little can be done to prevent catastrophe. In conclusion, we may say that control over the environmental pollution may not be possible unless society alters and organizes itself so as to be a part of the environment and not a defier of it.

HEALTH EDUCATION AND PRODUCTIVITY

Health is fundamental to national progress in any sphere. It is the measure of energy and productive capacity in any country. Loss of health affects productivity as well as efficiency in the national production. There is a direct relation between the nutrition and the productive capacity of an individual. In most parts of India, the diet is composed of cereals and it is lacking in protective and body building foods such as milk, meat, eggs, vegetables and fruits. Due to the religious taboos and poverty, the average amount of meat eaten in India is only four grams per person, per day. In the United States the average is 282 grams per person, per day. The problem of nutrition becomes more serious when the nutrients are destroyed by the adoption of wrong methods of cooking, such as overcooking or frying a thing again and again. Health education, therefore, is very important because it throws light on the various factors by which our life is affected.

To implement the programme of health education in India, the Central Health Bureau was established in 1956, in the Directorate General of Health Services. Several states have

also set up bureaux. Among the most important aspects of health education are: personal hygiene, environmental sanitation, prevention of communicable disease, nutrition, physical exercise, marriage guidance, pre-natal and post-natal care, maternity, child-birth, birth-control, etc. Health education may help an individual to reach his maximum level of productive capacity and in turn help him to live happily.

SUMMARY

The term health is vague. When we consider it from the point of view science and technology, we have to use it in the sense of public health. Public health is the art and science of maintaining, protecting and improving health of the people through organized community efforts. It includes almost everything from the field of social service and reform.

The scope of public health is wide. It evolved from mere sanitary measures to the concept of prevention of diseases and then it was regarded as an integration of sanitary science and medical science. Environment is supposed to be the first and basic stage of preventive medicine. The aim of improving environment was to eliminate harmful influences. The next step is to protect the individual himself by giving him experts' advice and health education.

The impact of bio-medical science on society is revolutionary. Vaccination and innoculation controlled the epidemic diseases. Man was relieved from many diseases due to the development of chemotheraphy. The modern antibiotics have virtually completed the conquest of bacrial infection and spirochaetal diseases including syphilis. Modern anaesthesia made surgery less difficult for both the patients and the surgeons. Clinical virology and the development of psychopharmacology made many people to live happily.

The medicinal treatment is being replaced by bio-engineering industries. It is reorganising the entire health system.

Environment pollution is a threat to the survival of human civilization. It is a global problem. Our basic needs such as food, water and air cannot be satisfied without pollutants affecting our health. The awareness of dangers of pollution and adaptability to technology are the only hopes for the human beings to live happily. Unless society alters and organizes itself to be a part of environment, it would not be possible to have control over the environmental pollution.

Productivity depends upon health. Health education is necessary because it can help an individual to reach his maximum level of productive capacity and in turn, help him to live happily.

EXERCISES

1. What is public health? What are the problems of public health?

2. What is the impact of bio-medical sciences on society?

3. "Bio-engineering industries may reorganise the entire health system." Explain.

4. What is environmental pollution? What are the major causes of environmental pollution.

5. Examine the problems of: (1) Water pollution, (2) Air pollution, and (3) Food pollution.

6. How is health related with productivity?

Chapter Ten

PRODUCTIVITY AND COMMUNICATION

Productivity — Technology and productivity — Trends of production processes — Communication — Development of communication system — Press — Radio and television — Relative advantages — Evaluation.

In this chapter we shall consider how science and its applications improved productivity and communications systems. Productivity and the problems related with it are really the problems of economics. Although communication is concerned with all human activities in general, so far as transmission of technical information is concerned, it is related with productivity. But, communication is entirely a different topics. Both the topics are dicussed in this chapter only for the sake of convenience. What is common to both the topics is the development and application of science which has changed the extension of the concepts of productivity and communication. From this point of view we shall discuss the nature of productivity and communication.

PRODUCTIVITY

The word productivity may mean the measurement of personal efficiency of labour or it may also mean the output derived from a composite bundle of resources. It is, no doubt, concerned with the techniques of production. The difficulty is to decide which of the countless methods that are technically feasible in principle are sufficiently commercially promising to be worth developing, in detail. Of course, no expert in the field of production will choose the techniques which are likely to prove uneconomic. For example, oilfired locomotives were probably feasible fifty years ago but would not have been considered worth developing in view of the relative economic prices of oil and coal, then prevailing. Even in the simple processes of

production, there are numerous alternatives which must be decided on the basis of cost, whether a control should be automatic or manual or whether bearings should be bronze or steel or whether the flow of materials should be mechanised or not These and other countless alternatives are essentially cost decisions within the framework of technical restraints.

Productivity is directly concerned with the economic problem of increasing the yield of available resources. The various factors such as time-series of output per man-hour at both industry and national levels, international comparisons and inter-plant and inter-firm studies have contributed an extensive factual knowledge of productivity. The understanding of both the causes and consequences of increasing productivity is required for solving certain pressing problems. If any policy is adopted without making an attempt to understand the basic causes of increased productivity, it would prove unsuccessful. Behind the productivity lie all the dynamic forces of economic life: technical progress, accumulation, enterprise and the institutional pattern of society.

Technology and Productivity

The industrial revolution was characterized by the substitution of powered machine production for handicrafts, increased efficiency of water transportation, development of new kinds of land transportation and more rapid transportation of information (i.e., communication). The substitution of machines for tool work done at home brought the dominance of factory as a method of industrial organization. Production had to be located where non-human power and access to raw material and markets were favourable. Machines could be grouped in a central building for greater efficiency in linking them together for integrated performance of tasks. Supervision of workers could be improved to reduce irregularities in quality and quantity of work. All these factors contribute for increased productivity.

"Early in 20th century mass production was introduced. Under the concept of continous flow, the materials move through a series of steps of processing. Workers perform the same task over and over in a specialization of jobs. The assem-

bly line brings the job to a worker who stays in one place. World War II brought automatic transfer machines which handle a piece of work, put it in proper position, fasten it in one place, perform some operation on it, release it and move it on to the next position. Automation involves automatic control in that the machine's own operation serves to regulate it to conform to predetermined objectives. A derivation from a desired quality activates a feedback readjustment. Electronic computers are provided information upon which machines act. Machines can thus control output, choose between alternative courses of action and correct themselves for changes in qualities of products, machine wear and so on. They can start, stop, accelerate, decelerate, count, inspect, test, remember, compare and measure qualities such as space and temperature." ("Social Problems of Urban Man" by Johnson). In short, automation is an integrated operation of a production system in which electronic and other equipments are used to regulate and co-ordinate the quantity and quality of production.

Trends of Production Processes

The satisfaction of direct human needs in a modern society implies a complex and scientifically inspired system of production. The common trends of all production process are the following:

(i) Automatic working, (ii) increased control of processes, (iii) automatic registration of conditions and products, (iv) continuity of processes, (v) increased speed of operation, (vi) dimunition of amount of goods at intermediate speed of operation, (vii) simplification of processes, (viii) dimunition of bulk and weight of machinery, (ix) rational and functional design and flexibility.

All these trends are called work-saving trends. They also save working and fixed capital. All these trends are possible due to recent technical and scientific advances.

COMMUNICATION

Communication is the transfer of information from a communicator (or transmitter) to a receiver. The information is transferred by "the medium" which is one of the basic factors

in communication. The medium may be "word of mouth" or simply talking to someone. Similarly, the medium may be one of the "mass media" such as newspapers, magazines, radio, television, etc. The nature of the medium affects the relationship between the communicator and the receiver. For example, speech is the medium of communication which is one of the causes of formation of societies whereas writing was the medium of communication by which civilization was advanced. The ability of writing is a major step in the development of civilization.

DEVELOPMENT OF COMMUNICATIONS SYSTEMS

The fundamental techniques of communication did not change much from the ancient civilizations to the classic societies of Greece and Rome. Dan Lacy in his 'Freedom and communications' says, "The capacity of ancient cultures to accumulate, to organize and to convey knowledge and hence to master their environment was determined by the capacity and efficiency of their communications systems. Similarly, the range of participation in the communications system—in the case of writing, how many copies could be made, how widely they could be distributed and how many people of what kinds could get copies and read them — determined the range of effective participation in the economy and in the government."

The next "great leap forward" in the history of western European civilization was the Renaissance. It was an age of widening communications in every sphere of life. It was the period of the rise of rationalism and the religious reforms, the science and literature and it was also the period of modern business and commerce. The invention of printing was a part of the Renaissance. Its effect was revolutionary increase in intellectual resources.

Due to the Industrial Revolution steam power was used to printing machines and mass communication in its modern sense became possible. The application of steam power to transport by railway and steamship enabled the vast potential output of books and newspapers to be transported to the millions of potential readers. Later on, due to the discovery of telegraph, the modern profession of journalism began. At the

same time important developments in communication took place viz. the establishment of effective publishing industry and the development of library. Now we are in the Atomic Age, the Electronic Age or the Computer Age. Electronic communication system which includes broadcasting by sound radio and television, electronic transfer of information by high speed digital data-links, computer controlled magnetic memories etc. are necessary for the new society. In short, the communications are more vital than ever and must travel at the speed of light. Let us now consider some of the common major communicators such as press, radio and television.

Press

The urban press is the most important medium of communication. A variety of material is included in the urban press, viz. (1) daily newspapers. (2) Special interest organs. (3) Periodicals. (4) Sensational Features and (5) Community Papers. Large cities offer a wide variety of newspapers, but they all may be owned and operated by one management or by a chain. The change is toward more mergers, resulting in the standardization of content, news, gatherings, release and distribution. Circulation has climbed, although the number of Independent papers has decreased.

Radio and Television

Other media, radio and television have contributed to ideational mobility and influences the acceptance and adoption of new behaviour pattern.

Radio: Radio plays a great role in the spreading of cultures and its influence has permeated the remote areas of the world where programmes are beamed from station in one country. Some of the effects of radio have been the increase of public education, mass entertainment and propaganda Human voice has greater power to sway emotions and under proper conditions the radio can unite the thoughts of many citizens on a national issue.

Television: An important new medium is television, invented in 1926 and introduced on a commercial scale when the world's fair opened in Chicago. The various programmes

are still in exploratory stage, but there are indications that this newer instrument will eclipse radio, press, wireless and other media in impact and scope. Television may bring about great changes in behaviour patterns, attitudes and beliefs. The social impact of television may be even greater than that of radio because visual appeal can be very effectively exploited.

Relative Advantages

There are essential differences between the media of telecasting, broadcasting and print. Press is slow in dissemination of printed information, broadcasting on the other hand transmits information at the speed of light and it usually reaches a very much larger audience than printed matter. Press preserves the content of information through the passage of time but broadcasting is essentially ephemeral. For example, a speech can be heard simultaneously by millions of people from the different corners of the world but broadcasting will have no record of the speech. On the contrary unless the speech is recorded on the magnetic tape or a journalist writes down his notes, it will not appear in the newspapers. It will take sometime to reach the written speech to the press and some more time to reach the reader.

Television has still more distinctive feature. The receiver employs two sources of sight and hearing when he observes a programme on television. Television has, therefore, the potentiality of conveying far more information in a given time to the receiver than press and radio. But television is more difficult to handle. There is another peculiarity of radio and television viz. there is no information regarding the number of people listening to or seeing the programme on radio or television, whereas, newspaper proprietor can know this information from the sale of the newspaper. This is advantageous to the proprietor of the newspaper because he can estimate his failure or success to some extent. However, broadcasting has inherent advantages over the press. It has socially and educationally answer to the problem of communicating an ever-increasing number of people. Broadcasting is the communication technology which is necessary in the electronic age both for rich industrial countries and developing nations.

Evaluation

The problem of communication is far more social than technical. We are moving towards a state when the ability of every individual to communicate freely and immediately with any other in as complete as possible is a definite and realizable goal. Where there is television, telephone service, the immediate future development will be towards cheapening this service and making it more accessible. It should ideally be possible for everyone to carry his own portable transmitting set for private circulation. The development of the more public forms of communication, cinema, radio and television is bound to exert an increasing influence. Radically new methods of communication and recording will need to be developed to abolish the senseless drudgery of the shorthand writer, the typist and printer.

Communication is an all pervading aspect of our social environment. It is not a social institution, but almost every social act, in every institution involves some communication. Of all the technical changes — changes in energy, in the techniques of industry, in the nature of weaponry the most fundamental and pervasive effects on human society have been the changes in communication. All the changes are due to a radical alterations in the perception of the average man. These changes have been brought by modern transportation and communication. Wherever change occurs in human society, there communication flows.

Modern media of communication developed in response to changing social culture. Uniformity of dress, language, new behaviour pattern, tastes and values are found in the urban area as a result of mass media while in less urbanised areas, norms, traditions and customs of the stable culture predominate, Social organizations are using these media to reinforce stable cultural elements. The diffusion of urban traits into rural areas has resulted in narrowing the gaps between urban and rural ways of life.

SUMMARY

Productivity may mean the measurement of personal efficiency of labour or it may also mean the output derived from a composite bundle of resources. It is concerned with the techniques of production. The

decision of selecting techniques of production are based on the cost production. Productivity is thus the economic problem of increasing the yield of available resources. It is important to understand the causes and consequences of increasing productivity before any policy is implemented.

The industrial revolution helped to increase productivity. Mass production started due to the development of technology. The quality and quantity of the work was improved. Automation improved the production system.

The trends of production processes have been developed to save work and also working and fixed capital. All these trends are possible due to technological and scientific advances.

Communication is the transfer of information from a communicator (or transmitter) to a receiver. The nature of the medium of communication affects the relationship between the communicator and the receiver. Writing is a medium of communication helped in the advancement of civilization and spreading culture.

The communications systems developed from speech, writing, printing, publishing industry and library, telegraph, newspapers, radio, television high-speed digital data-links and computer controlled magnetic memories.

The common major communicators are press, radio and television. They are called the mass-media because the communication with masses is possible through them. All these communicators have their own merits and limitations.

The problem of communication is far more social than technical. Rapidity and freeness in communication are the realizable goals Communication has the most fundamental and pervasive effect on human society. Any change in society is associated with the flow of communication.

EXERCISES

1. Explain the term 'productivity'.
2. How does technology influence productivity?
3. What do you understand by communication? What is the necessity of communication?
4. What are the advantages of radio, television and press in communication?
5. Write short notes on: (1) Radio, (2) Television, and (3) Press.

Chapter Eleven

THE MARCH OF SCIENCE AND TECHNOLOGY

Role of electricity in industry and agriculture — Electricity — Oil — Role of oil in modern life — Nuclear power — Role of nuclear power in medicine, agriculture and industry — Transportation — Role of mechanised transport system in modern life.

Energy and transportation system are, among others, the requisites of industrialization. Energy, is the very heart of machine. Transportation system shortens the distance between the producer and the consumer. Electricity, oil and nuclear power as sources of energy, and automobiles, steamships, railway and aeroplane as means of transportation, have brought changes in the industrial as well as social life. In what follows. we will see the nature and impact of energy as well as transportation.

ELECTRICITY

The first generator for producing electric current was built in 1831 by Michael Faraday. Faraday mounted 12 inch metal disk on an axle between the poles of a magnet. He rotated the disk through the magnetic field, by means of a crank. An electric current was generated and it followed through the connecting wires. Thomas A. Edison perfected the electric generator and put electric power to common use in the late 1800's and early 1900's. Edison invented the stockticker in 1869 and the photograph in 1877, both of which depended solely on the availability of the electric power. Edison was the first to have an idea to sell electricity as a carried of energy. This required distribution networks connected to a central power plant. The first such installation was the Pearl Street Power station in New York (in 1882). With the invention of the triode vacuum tube in 1907 by Lee Deforest, the United States entered the age of radio and

eventually television. Slowly and gradually computer came into existence. All these devices are dependent upon electricity for the delivery of energy—for their operation.

Power plant for producing electricity started using energy of falling water, a steam produced from nuclear reactors and fossil-fuel boiler. Electric power plants are generally away from the metropolitan areas at dam-sites or near sources of cooling water. The electric power is then transmitted to the user by means of transmission lines.

Electricity has many advantages. The greatest advantage of electrical energy is its flexibility, adaptability and ease with which it can be handled and controlled. The possibility of transmitting electrical energy in large blocks from the place of generation to the load centres, hundreds of kilometers away, and distributing it to the customers according to their requirements is a crowning advantage possessed by electricity. Further, electricity can be divided or combined with a little loss. It can be converted into heat, light and sound; into X-ray, radio television, radar, ultraviolet and waves of other frequencies and into mechanical power. It can be transported easily. quickly, silently and comparatively cheaply.

ROLE OF ELECTRICITY IN INDUSTRY AND AGRICULTURE

The role of energy in heating, lighting and motive power for industrial society is quite obvious. Electrical power has become the 'heart' of industry. Electricity is a steady, firm source of power which invites better machine tools. Automation refers to the moving of a procession of parts through a series of machine operations. The electronic machine is essentially a communication machine and must 'think' for the machine tool. When the electronic circuit is properly wired, a machine tool automatically proceeds to perform functions in accordance with electrical impulses transmitted to it.

The power age has stimulated the use of alloys and light metals. Cheap hydro-electric power has made aluminium an abundant metal. The airplane industry, has used aluminium in great quantity. The automobile and airplanes have greatly increased the transportation and have cut transport time. Force behind all this is electricity.

The power age is also characterised by the widespread adoption of the tractor and the electrification of farm. This has helped agriculture. Modern agriculture has become a significant direct consumer of energy. The production of fertilizers, chemicals, machinery and other inputs purchased by farmers depend upon energy. Electricity has contributed sufficiently to irrigation. Food-processing industry also accounts for a large share of the total energy use for agriculture. The introduction of energy-intensive farming changed our methods of farming and started to yield significant increase in farm output.

Further, transportation system has been revolutionized by electricity. Trains, motor cars, autos, etc. run on electricity. In short, the electricity has changed the structure of city, transportation, agriculture, business practices and agricultural designs, and has brought about social and economic change.

OIL

Oil has assumed an important and growing role as an energy source in the world. Its superior qualities and ease with which it can be transported made oil the preferred fuel after 1920. The result is that the industrialized nations' economy is heavily dependent upon the availability of oil.

There is no general agreement as to the origin of petroleum. Among scientists prevails a difference of opinion about the organic or inorganic origin of petroleum. However, the majority of the scientists believe that oil is formed from the remains of decomposed plant and animal life, which are carried alongwith mud, sand, etc., by water to settle on sea bottoms, in rivers, etc. and then buried in these sands and mud. The deposit of sand, mud, etc. has gone on for millions of years, and with the progressing span of years, the older beds of sand, mud and limestone, as well as plant and animal deposits, are buried under great thickness of similar deposits. By pressures and temperatures prevailing at those depths, as well as factors unknown to mankind, much of the plant and animal material is transformed into droplets of petroleum. These droplets are scattered through the various sands, clays, etc. These droplets collect together when there are some rocks to trap and hold them. These reservoirs later turn into 'pools of oil'.

In 1854, Abraham Gesner patented a process for distilling petroleum to produce illuminating gas and electricity. By 1859, others had distilled kerosene from coal which they called coal oil. This coal-oil was used for illumination. Edwin Drake followed the idea of drilling for oil, and the first drilling began in June 1859. Slowly and gradually, technologists developed the ways of obtaining oil, transporting it, refining it and marketing it.

ROLE OF OIL IN MODERN LIFE

1. **Petrochemicals:** Petroleum is the primary fuel for our transportation system. The automobile is totally dependent upon the availability of gasoline, a refinery product of petroleum. An oil refinery turns crude oil into gasoline, diesel oil, lubricating oil, kerosene and jet fuel. Gasoline is the chief product of a refinery and fuel oil of various grades ranks second in importance. Fuel oil is used to heat homes and buildings and to supply power for factories and railroads. Jet fuel contains a mixture of gasoline, kerosene and oil with low freezing points. Asphalt for roads is another product of crude oil. Petrochemicals are chemicals made from petroleum. Approximately 3,000 products are currently produced wholly or in part from petroleum in addition to 3,000 or so petrochemicals. Plastics, nylon, fertilizers and medical drugs are some of the petrochemicals. Organic chemicals of the carbolic acid type are obtained as a by-product from chemical processing of cracked petro-cracked products, both liquid and gaseous are made to yield many different varieties of resins, and plastic materials from which insulation materials and many moulded materials such as fountain pens and telephones are made. Synthetic rubbers are also manufactured from this source.

2. **Source of energy:** In the form of kerosene, oil illumines millions of homes in the countryside in every part of the world. As a generator of power, it moves the mightiest machines which give us articles of comfort and luxury. As a feeder of the internal combustion engine, it moves the cars. The transportation of goods and people is integral to the needs of any society. Transportation technologies have evolved over the centuries, and now people may travel long distances at high rates and speed. Automobiles increased individual mobility and influenc-

ed the shape of our cities, the range of vacation travel and our commuting habits. As we know, virtually every aspect of our life —industrial, commercial, cultural and recreational—is organized around the existence of automobiles. Oil plays an important role in giving energy to automobiles.

3. **Significance in war:** Oil is so important that wars are fought and won on oil. Lord Curzon had remarked: "The World War I was won for the Allies not only by blood, but by oil." After World War II Jubilant Winston Churchill said: "The Allies floated to victory on a wave of oil". Even the military leader of the vanquished nation, Germany, General Ludendorff, admitted, "It was chiefly because of insufficient oil resources in the World War that the German General staff was forced to sue for peace in November 1918.

NUCLEAR POWER

Roentgen discovered the X-ray in 1895 and then the study of radioactivity started. Becquered demonstrated that uranium gave off rays like the X-ray. Scientists started enquiry into the relation between energy and matter. German physicists, after a streneous research found that when high voltage is applied to two plates in a vacuum, rays are emitted from the negative plate. Great physicist Thompson showed that these rays consisted of minute particles, now known as 'electrons.' Milikan showed how electricity was atomic in character. He proved that the flow of electricity was the flow of electrons. Rutherford propounded a theory of transmutation of elements. He argued that the atom was like a solar system, with the proton occupying the central position at the nucleus and electrons moving in orbits.

Classical mechanics held that the electron in an atom would radiate energy due to its orbital motion and eventually would spiral down into the nucleus. Scientists believed that so far as radiation is concerned, all the energy of bodies must be finally transferred from the matter to radiation. For example, the molecules of air in a room should be finally at rest lying on the floor after transforming all their energy into radiation. But the facts of observation were to the contrary. Max Plank took up this work, and in 1899, he showed that the energy of a body was not wholly transformed into radiation, because radi-

ation comes in Quanta of energy. The ultimate particles of matter would therefore be moving. In 1932 Chadwick discovered 'neutron'. By this time the scientists had a clear picture of the structure of the atom. Thus scientists showed that 'proton' 'electron' and 'photon' are the constituents of atom. The finding of these constituents was made possible by powerful accelerators. The accelerator imparts tremendous energy to the bombarding particles for smashing the atomic nucleus or sub-nucleus particles. There are two methods of generating nuclear power—fission and fusion. Nucleur—fission gets its energy from large nuclei as they break up. Thermonuclear-fusion reactions yield energy when two light nuclei fuse together to form a heavier one. The fusion of one pound of deuterium-tritium mixture releases about the same amount of energy as fissioning of three pounds of uranium. This energy is equivalent to the energy obtained from as much as ten thousand tons of coal. Thus, one can imagine the tremendous power that is generated.

A nuclear-reactor power plant essentially depends upon uranium fuel. Man-made plutonium-239 is also suitable as a fuel in a nuclear reactor. The atom bomb and still more the hydrogen bomb, have caused new fears, involving new doubts as to the effect of science on human life. Some eminent scientists including Einstein, have pointed out that there is a danger of the extinction of all life on our planet. But we must remember that, though nuclear technology is a powerful military weapon, capable of causing destruction. it is also full of promise. It is of utmost benefit to mankind: for peaceful purposes it works miracles. Therefore. a massive international effort has been directed toward harnessing the enormous energy contained within the nucleus for peaceful purposes.

ROLE OF NUCLEAR POWER IN MEDICINE, AGRICULTURE AND INDUSTRY

Medicine: Radioisotopes have proved very useful in medicine both in therapy and for diagnosis of a variety of diseases. For instance, iodine-131 is used in the diagnosis and treatment of thyroid disorders. This isotope is the most frequently used isotope in medicine. Another important isotope used in medicine is phosphorus-32, which is produced by fast neutron irradiation of sulphur. The production of phospherous-32 has enabl-

ed the treatment of many cases of leukemia (blood cancer). Nuclear power has enabled scientists to study the behaviour of different elements in the human organism. With the help of nucleur power they can see how a drug acts on the human body and how the human cells react to drug.

Agriculture: Nucleur technology is very useful in agriculture. It is one of the major causes of high yields in agriculture. Mutations with desired qualities are produced by treating seeds with radioactive preparations. Achievements in the field of synthetic chemistry promise better utilization of farm products and the creation of artificial foods by purely chemical methods. Recent experiments at Cornell University dealt with sheep fed in the conventional way with natural grains and grasses, and with others which were raised exclusively on synthetic laboratory products. The latter were definitely superior in weight. wool and other important points. Further mechanisation of agriculture may mean the radar-controlled tractor. It has been demonstrated that on level land the tractor utilizing a single guiding apparatus can plough a field without a human operator. The pilotless tractor is no more impossible than the pilotless aircraft that is now an actuality.

Industry: Isotopes enable various industries to adopt modern processes of inspection and quality control. The most important isotope produced in this field is iradium-192 required for isotope radiography for non-destructive testing of welds and castings. By using sodium-24 one can determine the mixing efficiency and speed in viscose blenders in the rayon industry. Radioactive elements are used in oil-well and coal-mining operations. In chemical industry, isotopes help the chemist in seeing how chemicals behave in combinations. With isotopes one can study the bed silt movement in different harbours. This investigation is important as it enables a proper choice of a dumping site for material drudged from channels so that it does not return to the channels. Using such techniques, it is possible to advise port authorities on the choice of the right dumping sites. This sayes a considerable amount of money.

Finally, we may say that the control of atomic energy means that man has learnt to employ a third fundamentally different. type of force. Nuclear force is far more powerful than the

others. The prospect is that the release of atomic energy may eventually bring about an increase in available energy.

TRANSPORTATION

Transportation is the movement from place to place of persons or commodities by various instrumentalities of transportation. One of the outstanding contributions of economic and social progress in modern times has been the improvement of transportation services. In the early stages of the development of transportation there is tendency to devise new means of transportation. There is a tendency also to shift from one means of transportation to another in order to improve the efficiency of labour or to reduce cost. There is a tendency to shift from human porters to animals, because animals carry more weight. The 'wheel', in turn improves the efficiency of animal transportation, because greater weights can be transported to longer distances and at greater speed in wheeled vehicles. This led to the construction of roads and to improvement of road surfaces in order to reduce friction, and decrease cost.

The application of sails to water transportation had already transformed the water transport. Now, the application of steam to transportation early in the nineteenth century resulted in the reduction of cost and in the development of large-scale transportation. Slowly and gradually, steamship and steam railway came into existence, by 1830. For air transport, of course, the world had to wait till the twentieth century.

Let us take a brief survey of transportation technology.

In 1763 James Watt made a full size steam engine. He did lot of research on steam. This steam engine was not of much use because it could drive a shaft backward and forward only. It could not drive the wheel round. Watt made further research and by 1781 he perfected his steam engine. Now, the steam engine could be used for driving machinery in factory as well as the wheels of locomotives. In 1814, George Stevenson made a locomotive engine. Stevenson made further research and as a result of this research the first public railway was opened in 1825, between Stockton and Darlington in Britain. Transportation through water was the need of the time. Robert Fulton gave thought to it. He used steam engine in ship. He built a

steam ship in 1807. With the subsequent improvement on steamship, transportation by ship was made possible. A more convenient engine than the steam engine was necessary for road transport. So internal combustion engine runs on petrol or diesel oil. This engine found its most convenient application in the automobiles. Carl Benz made cars for sale in 1885. He is the pioneer of automobile industry. Rudolf Diesel made the diesel engine in 1898. This is the most popular engine in automobile industry. With further research, different types of automobiles designed for different purposes are manufactured. Automobile industry made road transport possible. Now, for transportation by air something was to be done. Wright brothers, Orville and Wilbur took up the challenege. After streneous work of years, they flew the first aeroplane in 1903. Flying got an impetus in the World War I. Scientists and technologists from many countries, notably America, Britain and France engaged themselves in improving airplane, and with their laborious efforts, transportation by air became a reality.

ROLE OF MECHANICAL TRANSPORT SYSTEM IN MODERN LIFE

(1) **Specialization and division of labor:** Transportation enables society to enjoy advantages of specialization and the division of labor by making it possible for products to be brought great distances. Before adequate transportation facilities were developed, it was necessary for each geographic region either to produce what was needed or to do without those products. With the advent of transportation system, today, it is possible to move goods to other regions. This makes possible the advantages of specialization. The regional division of labor lowers the cost of producing goods because the región of specialization enjoys productive advantagé over other locations. Sometimes it can produce a given commodity at less cost than is possible in the region with which it trades. Acquired skills tend to develop in the territory. Useful trade information becomes available and subsidiary industries grow up. Since region has an advantage in its specialty, society's total supply of the factor of production—land, labor and capital—is utilized most effectively.

(2) **Large-scale marketing:** As a result of specialization, it becomes further feasible to engage in large-scale production and marketing of goods. Although the market may expand through growth in the population of a given locality, the tendency has been toward its extension: Some historians say that broadening of the market by means of improved facilities for transportation and communication is the fundamental cause of growth of large-scale production. Transportation exerts its greatest influence upon production. It is the function of transport to supply the means to bring together the resources used in the productive processes and to markets for the resulting products. In other words, it is the function of transport to bridge the time and space gap between buyers and sellers. Transportation helps to lower the cost of producing goods and thus to reduce their prices. Because of the faster speed of the means of transportation, it is possible to broaden the market for perishable goods such as vegetables and fruits. Further, transportation promotes competition and tends to reduce the prices. Large-scale production has various advantages: one of the greatest advantages is the use of machinery. If the output is large, goods can be turned out much more economically by machine than by hand. And this results in the reduction of price.

(3) **Location of industry:** Transportation is one of the major sectors which influence the location of industry. The principle locational factors are markets, sources of raw materials, energy, labor and transportation. Of these the first four are to a large extent the products of transportation. Thus, cities like Bombay, New York, Chicago etc. are the desirable sites for many industries because of the transportation. Availability of raw materials also is the result of transportation. Technological changes in transportation, which modify the rate structure, have produced significant shifts in the location of industry.

(4) **Concentration of population:** Concentration of population is another effect of transportation. We find that the largest centres of population have usually been established where facilities for transportation exist. Since transportation helps large-scale production, it attracts large population in urban communities. People from country-side come to city in search

of jobs. Moreover, large cities depend for their existence upon adequate transportation. Food, clothing and fuel must be imported in large quantities often from distant places. We become painfully aware of our absolute dependence on transportation, when the railwaymen, busmen, taximen go on strike or somehow these services fail.

Transportation plays an important part in the marketing of the products of agriculture. Without efficient transportation and the refrigeration and heating services, perishable goods, like fruits and vegetables could not be marketed to distant places. Other agricultural crops also require motor, rail and water transportation services.

(5) **Social significance of transportation:** Transportation has many social advantages. Firstly, transportation raises the standard of living. In good old days, it was only the wealthy who enjoyed the benefits of products from many foreign countries. Transportation has broadened the outlook of the people. Because of the contact facilities provided by transportation, people do come to know different customs and traditions of different communities. This encourages tolerance and assimilation. The understanding is enhanced. In fact, cars, and buses, have virtually destroyed the rural isolation and have made possible strong social bonds.

Social effects of improved transportation are obvious at the local, national and international levels. Community life has been able to develop on a more expensive scale. Rural living today is much more closely associated with urban activity. At the national level, improved transportation has led to a better understanding of cultures. At the international level also it has played a significant role in the social and cultural fields.

(6) **Political significance of transportation:** Transportation strengthens national unity. Because the people can travel to far off places, a kind of homogeneity is created. Moreover, transportation makes the different parts of the country economically interdependent. In order to guarantee freedom of trade, a strong central government is necessary. For example, in a large country like India, there are many states. These states are interdependent for economic needs. Transportation promotes the easy move of economic goods. This interdependence

binds the people together. On many occasions, these sectional differences create problems. It seems that these differences would have been more serious, damaging and frequent in the absence of the unifying effects of transportation.

Second political advantage of transportation is the strengthening of national defence. This relationship between transportation and national defence has long been recognized by all governments. In ancient times this was the reason for which the great system of roads in Roman Empire emerged. Transportation by sea was decisive factor in the success of the Allies in both World War I and World War II. Transportation by railway, highway and air have their large share in war. Aircrafts are instruments of offence of incomparable potentialities. Against this no effective defence can be foreseen. Airplane has greater mobility, range and speed. It is effective in moving troops. and supplies as well as in bombarding. Railways, trucks, ships are equally important in war. As the director of the office of Defence Transportation of United States said while the World War II was in progress "we might suffer military reverses and still win the war, but we cannot avoid defeat should our railroad fail".

Transportation is one of the tools required by civilized man to bring order out of chaos. It reaches every phase and facet of our existence. Viewed from every standpoint — economic political and military it is unquestionably the most important industry in the world. The complete the life becomes, the more indispensable are the things that make up our transportation system.

SUMMARY

Energy and transportation system are, among others, the requisites of industrialization. Electricity, oil and nuclear energy as sources of energy and automobiles, steamship, railway and aeroplane as sources of transportation, have brought about changes in the industrial as well as social fields.

Electricity as a source of energy has many advantages. The greatest advantage of electricity is its flexibility, adaptability and ease with which it can be handled and controlled. It can be combined and divided with a little loss. It can be converted into heat, light and sound. It can be transported easily, quickly, silently and comparatively cheaply. Electrical energy has become the 'heart' of industry. In industry, it has work-

ed miracles. It has played an important role in green revolution. Because of electricity, adoption of tractors for agricultural purposes is made possible. Electricity has also made possible the production of fertilizers, chemicals, machinery and other inputs purchased by the farmer. Irrigation projects depend upon electricity. Transportation system depends upon electricity. Trains, autos, motor cars run on electricity. Thus, electricity has brought about significant social and economic changes.

Oil is another important source of energy. Oil has revolutionized the transportation system. Transportation system has increased individual mobility and has changed the shape of our cities. An oil refinery turns crude oil into gasoline, diesel oil, lubricating oil, kerosene and jet fuel. Fuel oil is used to heat homes and buildings and to supply power for factories and railroads. More than 3,000 petrochemicals are produced from oil. Plastics, nylon, fertilizers and medical drugs are some of the petrochemicals. Synthetic rubbers also are manufactured from oil. Oil plays an important role in war. Wars are fought for and on oil. Lord Curzon is said to have remarked. "The World War I was won for Allies not only by blood, but by oil".

Nuclear power is another source of energy. There are two methods of generating nuclear power — fission and fusion. Nuclear — fission gets its energy from large nuclei as they break up. The nuclear fusion reactions yield energy when two light nuclei fuse together to form a heavier one. Uranium and Plutonium are used as fuel in nuclear reactor power plant. Nuclear energy is very useful in medicine, agriculture and industry. In medicine, radio-isotopes have been used both in therapy as well as for diagnosis of certain diseases. Nuclear power has enabled scientists to study the behaviour of different elements in the human organism. In agriculture also nuclear power is used. Nuclear power is one of the major causes of high yields in agriculture. Mutations with desired qualities are produced by treating seeds with radioactive preparations. Lastly, nuclear power has enabled various industries to adopt modern processes of inspection and quality control. Radioactive elements are used in oil-well and coal-mining operations. Nuclear power has enabled the harbour authorities to study the bed silt movement in different harbours.

Transportation is the movement from place to place of persons or commodities by various means. We have road transport, rail transport, water transport and air transport. Scientists and technologists made various inventions in transportation system; and road transportation, rail transportation, water transportation and air transportation became a reality. Mechanized transport system plays an important role in our modern life. Mechanized transport system has made specialization and division of labour possible. Now, the people in a particular area need not produce all the necessities of their life. They can produce a specialized product which may be transported to the distant places and other commodities could be imported from those distant areas. This has given rise to large-scale marketing. Transport has bridged the distance between producer and consumers. Location of industry very much depends upon

transport system. Cities like Bombay, New York, Chicago etc. are the desirable sites for many industries because of the transportation. This has also resulted in the concentration of population. Largest centres of population have been established where facilities for transportation exist. People from country-side move to city in search of jobs. Transportation has not only an economic significance; it also has a social and political significance. Transportation has broadened the outlook of the people. Because of the contact facilities provided by transportation, people come to know customs and traditions of different communities. This encourages tolerance and assimiliation. Further, in the political field, transportation strengthens national unity. Transportation makes the different parts of the country economically interdependent. This interdependence binds the people together and creates homogeneity. Lastly, transportation plays an important role in war. Railways, trucks, ships and airplanes are all important in war. Thus, viewed from every point — economic, social, political and military, transportation is the most important industry in the world.

EXERCISES

1. What are the social and economic changes brought about by electricity?
2. What is the role played by oil in modern technological society?
3. Bring out the role of nuclear technology for peaceful purposes.
4. "Nuclear technology is of utmost benefit to mankind". Explain.
5. Explain the role of mechanised transport system in modern life.
6. What are the economic, social and political functions of mechanised transport system?

Chapter Twelve

TECHNOLOGY AND SOCIAL CHANGE

Causes of social change — Technology brings about social change — Science, technology and industrialisation — Automation — Family — Community — Interpersonal relations — War — Political control.

The most striking process in our present day culture is change. Society is undergoing change. Today, we find that societies are never static. Their membership changes; their achievements increase in number; their beliefs. ideologies, customs, etc., also change. New ideas are formed; new customs arise; novel social groups are born; and old ones die. Thus social change means modification of the behaviour of a large number of individuals.

Of all objects we can study, none changes so rapidly before our very eyes as the works of man, and particularly the social structure which he builds. For the physicist, biologist, astronomer, botanist, the territory he explores has remained essentially the same since men first sought to be scientist. But the territory which the sociologist explores changes even as he explores it. Society is not static. Society is becoming, not being. Of course, there are primitive societies which we think as stationery, partly because we know less about their past, partly because owing to the limits of their control over nature their relative seclusion, their smaller size and, therefore, greater homogeneity, the changes that occur are slower and less determinate. But, it would be wrong to assume that they are really unchanging. There is ceaseless change going in the universe. The man, though equipped with the experience of the past can never be certain of the future. In modifying his environment, man sets up a double process of social change. Certain social relationships are imposed upon him by his civilization, others

are imposed by him on his civilization. Keeping this in view, MacIver and Page point out that there are four universal conditions of social change. They are:

(1) The Physical Environment;

(2) The Biological Conditions;

(3) The Technological Order; and

(4) The Cultural Order.

(1) **The Physical Environment:** The surface of our planet is never at rest. There are slow geographical changes as well as occasional storms, earthquakes, floods, famines, etc. Similarly, we also find natural resources of particular regions exhausted. These factors drive people out of their homes to other regions where work is available and life is easier.

(2) **The Biological Factors:** The biological factors play an important role in personality formation. They determine the general direction in which individual's personality is likely to develop. The biological heredity determines the general and glandular constitution of the offspring which is intimately connected with temperament, intelligence and activity level. What makes the biological factors of change so important in human society is that they co-operate with the other factors of change initiated and developed by social beings as such. Each generation is a new beginning. The older generations transmit to the younger, with additions and modifications, the social heritage. The social heritage is cumulative. The greater the social heritage, the greater the potentiality of change. In human society, with its social heritage, the young cannot do over again just what the old have already done. Similarly, the new controls over both birth rate and death rate have constantly been changing the composition of the population.

(3) **Technological Order:** Inventions like aeroplane, radio, television, refregirator and the mass production of consumers' goods have added to human comfort and luxury; but they have also increased the number and complexity of our wants. The industrial revolution and labour-saving devices have brought about a new division of labour, a shift of population from village to town and a consequent change in the social structure. These commodities are theatening us with increased unemployment on one hand and so much of leisure on the other.

(4) **The Cultural Order:** It is in the very nature of culture to undergo change. In one aspect, culture is valuation; in another, it is expression. Valuations change with changing experience, whether the experience brings satisfaction or dissatisfaction. Every age has its own valuations. These valuations change with the times. What appeals to the father no more appeals to the children. The style of culture is dynamic. Similarly, in some periods, ideas of liberty and democracy gain dominance over wide areas, and in others, ideas of discipline and centralized order. In some periods, religious orthodoxy prevails and in others, religious non-conformity prevails.

Of all the factors of social change stated above, the technological factors are the most powerful. They bring about rapid changes in human relations than in the non-material culture. The reasons are quite obvious. Firstly, if the new inventions and techniques promise greater utility and do not disturb the larger social complex, they are accepted by the people wholeheartedly. On the other hand, the new ideas, beliefs, ideologies are not accepted, if they would involve a greater reorganization of culture complex. Secondly, the utility of one technique against another can be readily demonstrated and established. Everyone would agree that the automobile is superior in utility to a horse or a bullock-cart. Thirdly, manufacturer's ultimate motive is 'the profit'. As such, the changes in the manufacturing processes are readily adopted by the manufacturers as they promise greater profits.

On the other hand, it is a difficult task to determine the utility of one belief as compared to another. For instance, it is difficult to make out which belief leads to greater happiness, the belief in evolution or in divine creation. Further, the beliefs are rooted in the very personality structure of an individual and to question them is to threaten the integrity of the personality itself. Elliot and Merrill, therefore, rightly observe "Nothing changes so slowly as an idea. Once accepted, notices are invested with sacred connotations. Men will shed their blood to protect their beliefs in what is right, whether such beliefs involve religious ideas, political philosophies or economic theories."

Social scientists have coined the term 'cultural lag' to indicate this disparity and unequal growth in two parts of our culture, material and non-material. We usually adopt very readily new ways of building houses, new styles of furnishing them, new devices and machines to increase production; but we are rather slow to adopt new methods and ideas in education. Many of us are very modern in our ways of living but our religious and social ways at the time of marriage and death are the same old ones that prevailed centuries back.

Technology has two faces: One that is full of promise, and one that can discourage and defeat us. From one angle, technology might be deemed a blessing, from another an evil. We can explore the heavens with it, or destroy the whole world. We can cure disease, or poison entire population. We can free enslaved millions, or enslave millions more. Science and technology have added to our comforts, but also have created new complexities of life. Practically every area of social life, and the life of almost every individual, has been in some sense changed by the development of science and technology. In what follows, we shall see how development of science and technology has affected the social life and brought about social change.

INDUSTRIALIZATION

The Industrial Revolutions of 1540-1650 and 1760-1830 took place because of the change from wood to coal as fuel, the replacement of wood by iron as material, the substitution of horse, bull and water by steam-power and the application of multiple from single action in spinning. Hargreaves (a weaver and carpenter) invented the spinning-jenny in 1764, which enabled one person to control eighty or more spindles. Arkwright (a barber) invented a water-powered spinning in 1769, which used rollers and flyer, and produced a stronger thread than before. James Watt succeeded in improving the mechanical generation of power through steam. In 1785, Cartwright invented a powerloom. These inventions were followed by many others. These inventions brought about industrial revolution. As industrial revolution took place, the economic factor played a key role toward the movement of science. The practical success came to be seen in its contribution toward technical advancement and the industrial revolution.

The modern craft age was based on muscle and water power. The use of water wheels was a first significant step in the transition from animate to inanimate energy. The industry became centralized about good water-power sites. The steam engine provided a means for converting fuel into mechanical energy. This engine could be set up wherever fuel was available. Since, fuel could be transported, it was possible to locate industry more widely. Iron and coal exerted a powerful influence on the location of manufacturing. The equipment of modern industrial civilization is largely made of iron and steel. Machines, commercial and manufacturing, buildings and transportation facilities are all made primarily of steel. Most power and heat for industry as well as for rail transportation is obtained from coal. The power age is the age of electricity. The large modern factory using electric motors is a long, single-storey, shed-like structure which increasingly appears in the suburban location. Rapid growth of industrial complex is the result of electric power. Further, the atomic age provides a new fuel for power-stations. Heat can be developed and converted into electricity. The light weight of the fuel opens many possibilities for airplane and marine engines. Use of atomic energy in submarine and merchant ship shows the importance of this fuel.

AUTOMATION

Onset of industrialization brought considerable social change. The technology of a production system always has certain definite effects on the role of its workers. Industrial technology is marked by a high level of mechanization, standardization, specialization, automation and division of labour. The worker in industry may be engaged entirely in manufacturing one minute portion of an automobile or an aeroplane or a television. The trend of industrial production is toward a division of labour. The skilled worker may need good intelligence, judgement, considerable mechanical ability, visual activity, etc. On the other hand, for many jobs in the semi-skilled and particularly in the unskilled categories, these skills are either not needed at all or needed only in limited degrees. In the mechanization, the technical role of each worker depends upon the type of machines he is operating, its

size, its complexity, its source of power, whether it is mobile or immobile.

The machine technology has reduced the importance of the worker. Like the quality of the product, the speed of the process is controlled automatically. Machine has made a man a mere watcher of the system of production. Machine has not only reduced the man to insignificance, it has even made an extension of itself. Man has become a part of the machine itself. It is the machine which spins the cloth, which rolls the steel, which embosses the leather. Man is really reduced to an extension of the machine. Under these conditions, he may experience the sense of unimportance and lack of interest in the job.

Under a system of automation, material is handled and transferred automatically. Human beings are not used to feed the machine. Automation removes the worker from virtually all control over the production process. The quality of the work is controlled, the place of work is set entirely by the machinery, the need for human judgment is reduced by automatic inspection and automatic control. In the fully automated society, productivity would climb to unbelievable levels. A handful of workers could turn out what had formerly taken hundreds of thousands to produce. Thus, automation throws many workers out of the job. Technological changes in the steel, automobile, furniture, railroad, cotton and other industries have recently created large pools of unemployment which are not being rapidly absorbed by new industries. Similarly, certain industries decay, and the skills of many workers become obsolete. Older workers not only find it difficult to learn new skills but experience a deterioration of old skills.

Bernal has rightly remarked that "the scientific and computer age is necessarily a socialist one." But this alone would not suffice, and to quote from a joint study by the Soviet and Czechoslovak social scientists: "Scientific and technological progress alone can neither eliminate the exploitation of man by man nor provide conditions for the comprehensive development of man by man. This can be done only by means of a socialist revolution and a radical transformation of the entire society."

As a result, industrialism brings out another very important social change. This is the organized labour movement. Labour movement is a force with no ties to land or to family. This force makes its living only through employment in industry. The relationship between a working force and management is one of conflict. Management can fulfil its role only by curbing; to some extent, the working man's chance for achieving satisfaction in his role. The same thing is true of the working man in relationship to management. In the course of this conflict, the working force solidifies into a class and then evolves forms of organization.

Karl Marx says "Just as in the ancient world the interest of slave owners was opposed to that of the slave, and in the medieval Europe the interest of the Feudal Lords was opposed to that of serfs, so in our times the interest of the capital class, which derives its income from the ownership of property. is antagonistic to the interest of the proletariat class, which depends for its livelihood chiefly upon the sale of its labour power." Thus, the conflict between the workers and the management becomes a class-struggle. The workers may bring about many social changes. They may engage in picketing, demonstration, gherao, hunger strike or may engage in violent riots aimed at destruction of machinery or in strikes.

Labour organization is itself a great social change. This organization tries to curtail the freedom and power of the management. It tries to increase the labour's power. It may also appropriate to itself certain social functions which were formerly performed by another institutions and associations. Labour organization also affects the trends in politics and government. For example, special departments devoted to the problems of labour have become firmly established.

There is also a social change which results from what is produced by industrial technology. As the rate of production in technological era is faster, great quantities of commodities that were formerly rare, expensive and unavailable have become available to the people.

FAMILY

Scientific and technological innovations gave rise to industrialism; and industrialism had a revolutionizing impact

on the traditional family. In the traditional feudal family, there was a patriarchal father who ruled his family in a feudal manner. The power of the patriarch over his children, young, or old, was almost unlimited. He owed to his family certain rights and expected from them certain rights. The wife in this family was subordinate to her husband. Almost complete social subordination marked the position of the wife. She could not own property in her own right. She had no standing before the law over and against her husband. In eighteenth century England hardly any career was open to women—unless they were queens. A woman had few property rights beyond a dowery which went to her at her husband's death. On her marriage, her property belonged to her husband and even such earnings as she might acquire by her own labours belonged to her husband. At law, she was treated as a 'minor' or a 'ward'. Moreover, close relationships were maintained with families related by marriage or by blood. Since, families were quite stable and migration was not necessary, all relatives lived together. A whole neighbourhood or even a village might be made up of a few extended families. The extended family supported the smaller families within it. The extended family also enforced the traditional standards and values.

The marriage in the traditional family was not a matter of choice. Marriages were arranged. They were arranged in terms of socio-economic realities and not in terms of romantic attraction. Industrialism completely changed this picture of the family. As the development and the application of new techniques advanced, the family is stripped off its economic function. Innovations in science and technology have profoundly affected the whole character and social significance of the family. They took both the work and the workers out of the home. Industrialism separates the place of work from the place of family life, and in doing so, it pulls husbands away from wives, parents away from children and children away from parents. It breaks up the continuity of the traditional family. In industrial society, the family can no longer function as a face-to-face group. Industrialism has resulted in the transition from the joint family structure to that of the individual or nuclear family. It is true that some relatively well-to-do families, even when residing in city, keep their contact with

their families in the village. But this is not the case with the working class families who, when settled in the city and due particularly to lack of finance, scarcity of accommodation, feel forced to live in a nuclear family to which they easily become adjusted. Thus, industrialization has shattering effects on the extended family.

Industrialism radically changes the physical environment of the family. Because of the requirement of the job, the home is transferred from the city to the village or town, where residential place is scarce. Homes are crowded and also unattractive. This frustrates the family members. All attractions of urban life such as place of recreation, clubs, etc. are outside the home. As such the home becomes a place for meals and for sleeping, but other activities take a man outside the home.

Occupational Structure of Industry and Family: Unlike the farmer who worked perhaps within sight of his home, the modern man goes to work; that is, he leaves his family for eight hours or more a day. What he does in place of work is usually incomprehensible to his family. The child or the wife is thus cut off from the occupational world almost completely. Further, the particular occupation which an individual follows in industry determines many immediate aspects of family living. For instance, the occupation determines the amount of income which the family will live on. Occupation also determines the time which the job holder will spend in the home, whether that time will be in the day or in the night. Occupations create tensions and strains, which may be and many times are transferred to family life.

Change in the Central Function of the Family: The basic function of the family is the procreation and socialization of children. But science and technology have brought about many changes in this central activity of the family. Various medical and social agencies have been developed to aid the family in its principal function. Maternity hospitals and outpatient clinics for mothers, the baby clinic, the kindergarten and other preschool agencies are helping the family. Invention of contraceptives has tended to decrease the rate of procreation. The role of mother in the family is drastically altered by the cook-

ing gas, washing machine, the refrigerator, canned foods and a host of other labour saving products. Thus, the modern technology as well as the practice of birth prevention have freed modern woman from the drudgery of home and children, have afforded her opportunities of enjoying leisure.

Changes in the Structure of the Family: Because of the labour-saving devices the modern woman has so much of time at her leisure. The desire to escape boredom and loneliness at home and to gain companionship at work is the motivating force for the modern woman to take up a job. In Britain, women constitute one-third of the labour-force, and of these, nearly two-thirds are married. Survey-figures show that the proportion of all married women gainfully employed has risen steeply over the last few decades. It was 9 per cent in 1921, 21 per cent in 1951, 32 per cent in 1961 and 47 per cent in 1972. To encourage the employment of married women, some factories have introduced special shifts, allowing time for married women to do their domestic duties. With the introduction of technologically sophisticated machines, manual work has become lighter and easier to woman. With the growth of opportunities for married women to work, the pattern of the dual-career family has become increasingly widespread. The dual-career family is one in which both husband and wife work continuously at the occupations as well as taking on domestic roles. Under these circumstances, both husband and wife have to overcome the criticism based on traditional sex roles.

Industry, directly or indirectly, helps to shape the roles that are played within the family. Technological changes have broken down the age-old doctrine—"man for the field and woman for the hearth." The degree of economic independence already achieved has significant results. Formerly the young woman had no alternatives beyond an early marriage or continued dependence upon the parental home. Now she can earn her own living and thus gain a sense of independence. This sense of independence affects her whole attitude, gives her more power to choose when and whom she shall marry. Further, the modern family is marked by a relatively great degree of equality of roles. The husband is less of an authoritarian figure than in the patriarchal family. He cannot command the obe-

dience of his wife to nearly the same degree that the patriarch could. The husband in the modern family must adjust his personality to the emotional needs of his wife. Thus, the process of modern civilization has worked toward giving woman a new position in society and especially in their relations to men. The working class woman need not be tied to her husband through economic needs nor is she committed to him because she is dependent on him for her status position. As a result, in a family crisis, she may seek a way out by going to work, or she may even choose dissolution of marriage.

Industry and the Role of Children: In an earlier day, industry had a more direct influence on large number of children. In 1870, when the development of industry due to scientific and technological innovations began, almost one out of every five boys between the ages of 10 and 15 was working and about one out of every 14 girls of that same age was employed. The year 1900 was the peak year in the employment of children. About one in four of boys between 10 and 15 was working and about one in ten of the girls. Of course, today in many countries the institution of child labour is abolished. The law specifies that an individual below a particular age should not be forced to work. Today, industrialism is no longer a direct influence on children; still, the child is influenced by industry at all levels. To take an example, in the family where both the parents are working, the care and raising of the child is left in the hands of nurses. Under this circumstance, the socialization of the child is either lacking completely or inadequate.

COMMUNITY

Scientific and technological innovations disturbed the traditional community life. Before the industrial revolution, the technical organization remained relatively stable. A balanced adjustment between work and community-life was the rule. With the advent of industrialism, the technical organization changed. Profit was derived not only by improving machinery but also by improving work organization. Technical and mechanical alterations forced changes in the organization of workers. An industrial system demands labour which can be depended on to report to each day and on time. which can b

quickly called back to work after a period of lay-off, and which will have no other source of livelihood than the industry. In order to create or to find such a supply of labour, industry had either to enter already existing communities where a labour force existed, or to create communities into which the labour force could be attracted. In order to cut transportation costs, and to keep pace with the changes in the fashions of urban population, the industries were set up in the urban area. Naturally, the rural population shifted to cities in search of jobs. An industrial working force must be mobile because an industry must be ready to move at any time to take advantage of new resources, new sources of power, new markets, etc. Further, industrialism aims at maximum profits. If the goal of maximum profit is to be achieved, then many important communities must be discarded. In developing industry, a labour is treated as a commodity. The relationships between management and labour are impersonal, transitory and ruthlessly oriented to self-interest. It is no wonder then, that industrialism has shattered the traditional community. Traditional communities were based on shared values. The urban community has only superficial things in common—a fad, a taste, a fashion. The symbols of traditional communities were customs, traditions and folkways. But, in the absence of these, the symbols of the urban order are the policeman, the court and the law. The lack of unity in urban-industrial communities contrasts sharply to the situation which exists in the traditional community. Further, in industry the workers from different religious and racial background are thrown together. This quickly shatters the unity of the old community.

Technological changes also affect the relations in a community. Warner and Low have stated how changes in the technology of the shoe industry changed social relations both in and outside the factory. They have shown that during the early factory period the skill hierarchy dominated workers' lives and fixed their status positions in the community. The hierarchy of crafts was an age-grade system through which young men expected to pass. The mechanization of shoe production largely destroyed the skill hierarchy and the age-grade system. Skilled workers became semi-skilled, and semi-skilled workers remained on that level. Since young men had no hope

of jobs requiring greater skills, they lost hope and security. The older people also lost security and status.

However, we must remember that the social changes that technology brings to the community are not the result of purposeful and intentional behaviour on the part of industrialists. The desire to introduce technological innovations springs largely from an attempt to cut costs and operate more efficiently. The general consequence of the urbanization of the community is the weakening or suppression of the local or traditional cultures. In the new urban centres arises a technological order. Some sort of economic rationality develops, and new crafts arise. People of different cultural backgrounds meet bring new ideas, nationalism flourishes there, nativistic leaders and reformers arise there, and people look more to the future than to the present.

Problems also arise because of the moving about of people. The nature of the problem depends on how much moving about is done and by which section of the population. It would be mobility if family changes residence from one part of the country to another. Varieties of movement identified as mobility would include

(1) One may change his place of residence but retain his place of work;

(2) He may change his place of work but retain his place of residence;

(3) He may change from one kind of work to another kind, calling for different skills and capabilities and yielding a different rate of pay, which is occupational mobility;

(4) One may change from one social class to another as his income rises or falls, which is social mobility.

Occupational mobility, residential mobility and social mobility being related in some cases may take place about the same time.

Social problems arising out of mobility and migration are great. The person who moves becomes involved in one situation in the place of his origin and later another in the place of destination. The migrant leaves the place of origin, family and

friends to whom he may have obligations. He may continue to retain rights or hold property in the place of origin. Often the assumption is that he will return. At the place of destination he wins friends, acquires property and he may also assume obligations. He finds himself torn between obligations, between new interests and old ones, on the other hand he may find at the place of his destination and feel himself degraded at the place of origin. Demands made upon him at the place of origin may exceed his ability to play. On the other hand, if he is successful in the place of destination, he may endeavour to evade his obligations at the place of origin. The problem assumes one aspect in the place of origin and quite another in the place of destination.

The whole pattern of rural community also has been revolutionized by the tractor and automobile. With new road, emigrants can make trips to several hundred miles with less difficulty than their parents had in migrating for twenty-five. Today city, while still a foreign world, has become much less strange to the villages than it was a generation ago. Farmers sons educated in the city enter medicine, law and other high-prestige professions. These men and their families maintain contact with their native villages and visits back and forth are frequent. Many new ideas and attitudes and changes in style of life are brought to village families by city relatives. Moreover, radio and television provide information about urban life previously lacking to farmers. This as well as increasing opportunity to make short trips to cities with relatives who have previously migrated removes much of the traditional apprehension felt by the villagers for the urban centres. As a result, there is increasing acceptance of the outsider's ways particularly by the younger generations. This leads to the rejection of a great deal of indigenous culture and tradition. The validity of earlier customs is denied, and people who cling to old ways are taunted as old-fashioned.

INTERPERSONAL RELATIONS

Science and technology brought about industrialization. Industrialization has its great impact on interpersonal relations. In the pre-industrial era, family was the basic unit, then the community. Man thought of everything in terms of his

family and community. His relationship was limited to his family and community. The relationship was direct and personal. Emotional bonds existed in such a relationship. Man was the head of the family and everyone including his wife had to play a subordinate role. Industrialization changed this picture completely.

(1) **Relation Between Husband and Wife:** The modern family is marked by a relatively great degree of equality of roles. The husband is less of an authoritarian figure than in the patriarchal family. He cannot command the obedience of his wife to nearly the same degree that the patriarch could The working class woman need not be tied to her husband through economic need nor is she committed to him because she is dependent on him for her status position. Industrialization and modernization have given woman a new position in society. Thus the industrialization has changed the relation between husband and wife.

(2) **Relations Between Parents and Children:** Industrialization has its impact also on the relation between parents and children. In pre-industrial era, children had sufficient socialization through their parents and grand parents. Because of the breaking of the joint-family system, and also because of the individual mobility, the children are deprived of the socialization from grand parents. Urbanization with its complex problems. does not allow the parents to have longer time and close association with their children. In the family where both the parents are working, the care and raising of the child is left in the hands of nurses.

(3) **Relationship Widens:** In the pre-industrial era, men thought of everything in terms of his family and community. His interpersonal relationship was confined to his family and community. But today, his relationship is becoming less and less kinship based and his interpersonal relationship is widening. Industrialization has drawn man out of his rural family and community. When he comes to city in search of job a settles down there, he gets to know many people—neighbo co-workrs, co-travellers in bus, train, etc. However, the no emotional involvement in this relationship.

(4) **There is no Emotional Involvement:** Urban man has more or less impersonal relationships with most of the people he comes in contact. He cannot emotionally or otherwise involve himself completely with everyone. So long as the fruit-seller performs his duty selling fruits, an urban man does not bother about the fruitseller's religion, language, his political view or views on art. Urban man has neither time nor interest to involve completely with everyone. The reason is obvious. The average urban man today probably comes into contact with more people in a week than the pre-industrial era villager did in a year, perhaps even a life-time. Urban man has to interact with hundreds of people around him.

(5) **Short–term Relationship due to Mobility:** Most of the people a villager knew were the same throughout his life. But so far as urban man is concerned, the neighbour relationships are no longer regarded as long-term relations. Urbanization dictates individual mobility. Individual has to move from place to place. As such neighbour relationships last as long as the individual remains in a single location. Moving leads to the termination of relationships. When an individual moves to some other place, he leaves behind his parents, in-laws, neighbours, co-workers, and many others. Emotional ties are upset. When he settles down in the new community he has to take initiative in building new relationships. Thus today we find that there is a decrease in the duration of interperonal relationships.

(6) **Technological Innovations:** Technology brings many innovations. These innovations have their impact on the interests and aptitudes of the people. There is a saying 'birds of the same feathers flock together'. Friendship is based upon shared interests and aptitudes. With new innovations, interests and aptitudes are bound to change. And with new interests and aptitudes, friendship relationships are bound to change Thus today an urban man seeks out new friends to replace those who are either no longer present or who no longer share the same interest.

Lastly, science and technology have brought about revolution in the means of communication. The means like radio, television, newspaper, film, telephone, have to a large extent

interfered with interpersonal relationships. Because of telephone, face to face relations are minimized to a large extent. An individual can contact other people on phone. Similarly, films, radio, television and newspapers have reduced contacts to a considerable extent. This is quite obvious from the fact that when there is a good programme either on television or on radio, people normally are reluctant to visit their friend's or neighbour's house.

WAR

With the emergence of technologically sophisticated weapons, war has become a scientific affair. The findings and inventions of science and technology have always been utilised in the war. By developing the art of seige the Persians found it possible to bring vast areas under a homogeneous organization. The Macedonians under Alexander commanded an immensely superior technique for breaking through city walls. This engineering technique of Macedonians and Greeks was taken over by the Romans and carried to such an efficiency that a walled city came to be rathera trap for the enemy forces than an obstacle in the conqueror's path.

The effects of modern technology in the warfare are decisive. The world war revealed how rapidly technical progress can move and how profound its effects can be. The deadlock of open warfare, the maintenance of armies of millions of men, and the fact that attack could be made only after several months of preparation—all these were results as well as causes of the modern technique of warfare. The rapid development of new war-technologies, such as aeroplane, the tank and the machine gun, and of new techniques in the production of explosives, was probably the most salient contribution of the First World War. During this period only, the chemical warfare methods and poisonous gases were developed.

That the modern war has been a scientific affair was recognised by the politicians and the rulers. This is evidenced by the speeches of Stafford Cripps, then a member of the War Cabinet in Britain, in 1941. He said: "I think our main difficulty with regard to the proper utilization of the scientists in this war has been the failure to realise at a sufficiently early

stage that this was going to be a truly scientific war and that the battle would not be won merely by the physical ascendancy of our race, but by the ingenuity of those who have been trained in our schools, technical colleges and universities."

In Britain, war accelerated the development of radar and the setting up of a number of further Air Ministry Units such as that of telecommunication. Churchill set up a Ministry of Aircraft Production under Lord Beaverbrook. There was a steady influx of university scientists into war research and development. Many, such as Blackett and Hill, were already involved, but new names like John Cockcroft appeared who were later to work on the atomic bomb.

As far back as 1938, the Royal Society had prepared a memorandum on peacetime organization for voluntary training of scientific workers for service in the case of a national emergency. Thus, by the beginning of the war, there was a fairly competitive register available of qualified scientists and engineers. This register reveals that by the 1940 there were 1175 physicists in Britain compared with 4000 in the U.S.A. Thus, the onset of war found British scientists in a greater state of readiness, and British government in a more responsive frame of mind to their use than in 1914. Penicillin also was developed around this time to help with the treatment of wounds.

History of science shows that findings of science and technology have been utilised in the war. Archimedes had been employed by the Tyrant of Syracuse for use against the Romans. Galileo had been employed by the Grand Duke of Tuscany to calculate the trajectories of projectiles. And beyond doubt, the two world wars were the wars of the scientists. Thousands of scientists were employed to invent the techniques of killing enemy. We also learn that, despite their more sophisticated military potential, scientists were initially drafted into the war effort as conventional soldiers.

The letter of Leonardo Da Vinci (1452-1519), one of the two great scientists of the Renaissance, while applying for the post with the Duke of Milan provides the best example of the scientists' contribution to war.

"Having, most illustrious Sir, seen and considered the experiments of all those who profess to be masters in the art

of invention of the apparatus of war, and having found that their instruments do not differ materially from those in general use, I make known to your excellency certain secrets of my own, briefly enumerated as follows:

(1) I have a process for the construction of very light bridges capable of easy transport, by means of which the enemy may be pursued and put to flight, and of others more solid, which will resist both fire and sword, and which are easily lowered or raised. I know also of a means to burn and destroy hostile bridges.

(2) In case of the investment of a place, I know how to drain moats and construct scaling ladders and other such apparatus.

(3) Then, if by reason of its elevation of strength, it is possible to bombard a hostile position, I have a means of destruction by mining provided the foundations of the fortress are not rock.

(4) I know also how to make light cannon easy to transport capable of ejecting inflammable matter, the smoke from which would cause terror, destruction and confusion among the enemy.

(5) by means of narrow and tortuous subterranean tunnels, dug without noise, I am able to create a passage in inaccessible places, even under rivers.

(6) I know how to construct secure and covered wagons for the transport of guns into the enemy's lines, and not to be impeded by ever so dense a mass, and behind which infantry can follow without any danger.

(7) I can make cannon, mortars, and engines of fire, etc. of form both useful and beautiful, and different from those at present in use.

(8) Or, if the use of cannon happens to be impracticable, I can replace them by catapults and other admirable projecting weapons at present unknown; in short, where such is the case I am able to devise endless means of attack.

(9) And, if the combat should be at sea, I have numerous most powerful engines both for attack and defence; and

ships which are gun-proof and fire-proof; and also powers and inflammables.

(10) In times of peace, I believe that I can compete with anyone in architecture, and in the construction of both public and private monuments and in the building of canals; I am able to execute statues in marble, bronze and clay, in painting I can do as well as anyone else. In particular I will undertake to execute the bronze horse in the eternal memory of your father and of the very illustrious house of Sforza. and if any of the above mentioned things appear to you impossible or impracticable. I will offer to make an attempt at it in your part or in any other place which your excellency may please to choose. to which I commend myself in all humility."

Modern engines of warfare are terribly destructive of human life and property. Bombers. fighters and other kinds of aeroplanes destroy not only military areas. but also civil population and industrial areas. Parachutists suddenly swoop upon people, and paralyse their peaceful civil life. Modern war. with its most destructive weapons, is the most terrific evil that has affected the human race. Tragedy in Hiroshima and Nagasaki is the example that can be cited in this connection.

Biological warfare and chemical warfare are the innovations in modern warfare. Biological warfare is a kind of warfare in which disease-producing germs and their products are used against man, animals, food crops and plants by the enemy. A number of infectious diseases are used as agents in biological warfare. Some of them are: Anthrax. cholera, dysentery, influenza, plague, pneumonia. tuberculosis, small-pox, cow-pox, etc. These agents kill human beings, animals and plants. There is a spread of epidemics in the infected area.

In chemical warfare, agents like choking gases, vomiting gases, blood gases, nerve gases, incapacitating agents are used. These gases when dispersed, kill human beings, animals and plants. In World War I, 12,000 tons of mustard gas caused 400,000 casualties. Napalm and other chemical gents have in the recent past played havoc in Viet Nam. The gases killed innumerable human beings, animals and plants.

Chemical and biological warfare agents have given new shape to Modern Warfare.

Furthermore, modern sophisticated weapons involve big money. The importance of war finance in the modern period is reflected in the fact that even in peace time military outlays account for the largest single item in public expenditure. In Prussia in the eighteenth century the proportion of public funds diverted to military purposes amounted roughly to form two-thirds to four-fifths of the total central expenditure of the government. With the extension of governmental functions into the field of cultural, social and economic activities, the proportion of military expenditure declined. Before war, it constituted in most countries from 20 to 40 per cent of the total expenditure. Since, the world war, of course, the military expenditure declined. But the fact remains that even today every nation is curious enough to possess technologically sophisticated weapons for military purposes.

POLITICAL CONTROL

Politics is the science and art of government. The term covers the entire field of political life and behaviour. It embraces the relations between the state and the individual. It includes the relation between the state and its political sub-divisions and between state and other states. Politics denotes man's struggle for social power. Technology, on the other hand, represents the set of means by which man puts the forces and laws of nature to use and attempts to improve his environment. Let us discuss now, the impact of technology on politics.

Since technology exerts its influence on society, it also affects the exercise of social power and authority. Many technological innovations in nineteenth century, as we know, had political consequences. These innovations changed the face of the society and political order. The innovations gave rise to industrial revolution and the growth of urban society. Technological progress both altered the ruling classes and brought entirely new elements to power. The advance of technology became a factor both within government and in ihe struggle over it.

Man's Participation

Man's relation to technology gives rise to certain ideals. The aim of technology is to better human existence and make it more comfortable. Man has a strong desire for comfort. Technology proves to man that his desire for comfort is realizable. The achievements of technology make the aspiration to comfort possible. The widened participation in social power does not only mean participation in government, but also the sharing of achievements of society. In the technological civilization, this does not imply the control of the means of production—but also participation in the achievements of technology. Further, technology can very well stimulate the aspiration to share the control over the means of production. Thus, the achievements of technology indirectly influence the demands of man. The government is always faced with the problem of satisfaction of the demands of the people. And, since the aim of technology is the satisfaction of human demands, it also influences the world of politics.

It may be argued that the achievements of technology is an illusion, for in times of mass unemployment, technological achievements will be of no avail. In this case we must remember that these illusions themselves become a strong social and political force. The idea of the 'Welfare State' came into existence because of technology. There are two sides to the idea of the welfare state. On the one hand, society must help man by seeing to it that the technological achievements should not be monopolized by the privileged few, but be shared by all. The state is called upon to mediate here. We can see the impact of technology on politics from another angle also. Man demands from the state that as the technology improves, the state should try to improve the human existence. The improvement of technology is transferred from the technical realm of objects and machines to the realm of society and its institutions. Man measures his environment by a technical-utilitarian yardstick.

Equality in Style of Living

Darwinism contended that men are not congenitally equal and evolution proceeds by selection. It assigned importance to heredity in producing a good adult apart from environment and

training. The thought that men are not equal in congenital endowment had a disastrous effect on later political philosophy. Nietzsche and Nazis singled out particular race and the superman as superior to all others. And, as we know, this resulted in tragic consequences during the Second World War.

There are three types of inequality:

(1) Inequality of ancestry;

(2) Inequality in personal power; and

(3) Inequality in affluence.

Until technological civilization prevailed, it was more or less clear that inequalities in one of its three categories, leads to inequality in actual human life, in man's way of life, the opportunities offered to him, etc. But, technology brought an equality of style. This is not to say that technological civilization has replaced inequality with equality or removed the essential roots of human inequality. However, technological civilization does aim at equality. Technological civilization surrounds a man with devices, and through them creates a way of life that man must accept because of their very presence. It abolishes habits and ways of life, and introduces a style of uniformity. This uniformity of style creates an outwardly human equality. This is an atmosphere for the growth of a complex psychological reaction. Instead of paying attention to inequality, we tend to fix our eyes on equality. This equalitarian frame of mind brings about a particular type of political behaviour. He who adopts this way of thinking, does not hold an image of politicians or for that matter of any person in power as having superhuman qualities and powers.

Bureaucracy

Politics is the management of the affairs of the society. Technology influences politics in this respect. Technology is one of the processes that increases and intensifies the bureaucratic character of the State. Bureaucracy is the applied science of management. The bureaucracy requires various business machines, from typewriters — through the complex machines that compute the results of election and population movement to advanced electronic computers. This very dependence of the

political machine upon technology speaks of impact of technology on politics.

Shaping Public Opinion

In the world of politics, public opinion has been recognized as a great social force, since it regulates and controls public life. According to W. J. H. Sprott, "Public Opinion is more of a conscious attitude or the line which the people take in relation to an issue. It is usually emotionally charged. It involves beliefs, accepted principles, convictions, sentiments and also fairly rooted prejudices."

Politicians are very much concerned with public opinion. They aim at moulding the public opinion. Public opinion becomes clearly defined when the media of mass communication are very effective. Here, the politicians depend on technological innovations—newspapers, radio, television and films.

Newspapers havethe most powerful influence in the formation and propagation of public opinion. They make a very powerful appeal by their headlines, emotional catch-words, etc. They reach a very large variety of people and help to create the impression that there is a consensus of opinion about various issues. The cinema is a medium of entertainment, but is also effective in shaping public opinion. Radio and to some extent television, have overcome the limits of time and space Radio and television create the illusion of experiences within one's intimate world. Access to the mass media is a crucial element in political power in the modern society. Technological advances in the field of newspaper, printing, publishing and films, radio and television have made it possible to reach great masses of people. A political message can now reach a large portion of the electorate within a very short period of time.

Penetration of technology into politics creates a sort of substitute for direct democracy. It is true that not the entire electorate can participate directly in the decision-making, for these people are ruled by representatives—and in this sense it is still the representative democracy, yet technology does make possible another sort of participation observer—participation with decision. This is obvious when we see any programme on political issue on television.

SUMMARY

There are four conditions of social change. They are

(1) The physical environment;

(2) The biological conditions;

(3) The technological order; and

(4) The cultural order.

Of all the factors of social change, technological factors are the most powerful. They bring about social changes rapidly. Practically every area of social life and the life of almost every, individual, has been changed by the development of science and technology.

Scientific and technological innovations are responsible for industrialization. Industrialization in turn brought about considerable social change. Industrial technology is marked by a high level of specialization, mechanization, automation and division of labour. The machine technology has reduced the importance of the worker. Machine has made man an extension of itself. It is the machine that determines the worker's actions, the energy he will expend and so on. Automation throws many workers out of job. A handful of workers can turn out what had formerly taken hundreds of workers. This creates large pools of unemployment. Unemployment gives rise to another social change — organided labour movement. The relationship between a working force and management is one of conflict.

Industrialization had a revolutionizing impact on the traditional family. As the development and the application of new techniques advanced, the family is stripped off its economic function. Scientific innovations took both the work and the worker out of the home. Industrialization has caused changes in the central function of the family. And also the changes in the roles. Industrialism has affected the community life. Technological and mechanical alterations forced changes in the organization of workers. There is a social mobility. The rural population shifts to cities in search of jobs. Technological changes also affect the relations in a community. The general consequence of the urbanization of the community is the weakening or suppression of traditional cultures. The whole pattern of rural community also has been revolutionized by technological innovations.

Science and technology have also greatly influenced warfare. With the emergence of technologically sophisticated weapons, war has become a scientific affair.

Technology also influences the political control. Politics denotes man's struggle for social power. Now, since technology exerts its influence on society, it also affects the exercise of social power and authority. Many technological innovations in the nineteenth century had political consequences. These innovations changed the society and political order. They gave rise to industrial revolution and the growth of urban society. Technology stimulates the aspirations to share the control over the means of

production. The government is always faced with the problem of satisfaction of the demands of the people; and science and technology always work in this direction. Scientific and technological innovations bring a kind of uniformity in style of living. This uniformity of style creates an outwardly human equality. Technology is one of the processes that increase and intensify the bureaucratic character of the state. Lastly, in the political field, public opinion is a great force. Politicians are always concerned with the public opinion. They aim at moulding the public opinion. Newspapers, radio, television — technological innovations — help politicians to shape public opinion. Penetration of technology into politics also creates a sort of substitute for direct democracy.

EXERCISES

1. What are the main causes of social change?
2. What is industrialization? Describe the changes brought about by industrialization?
3. How does automation affect a working class?
4. How do science and technology bring about changes in the family structure?
5. How does industrialization affect interpersonal relations?
6. How do science and technology influence community?
7. Bring out the role of science and technology in modern warfare
8. "Today war has become a scientific affair". Do you agree?
9. Discuss the impact of science and technology on politics?
10. Bring out the stresses and strains created by technology of the twentieth century?

Chapter Thirteen

CULTURAL IMPACT OF SCIENCE AND TECHNOLOGY

Culture — Printing press and the spread of knowledge — Mass media and cultural dissemination. (The news papers — the broadcasting media — film).

CULTURE

Culture is a social heritage of the people. The communities are not simply crowds, groups of people who happen to be physically close to one another. They are societies; organized groups of people who have learned to live and work together, interacting in the pursuit of common ends. Community has a structure or an organization. Its members quite unconsciously agree on the basic rules for living together. Culture is the shorthand term for these rules that guide the way of life of the members of a social group. Culture implies heritage, transmission of modes of acting, feeling and thinking from generation to generation. There are the material as well as the non-material aspects of the culture. There are the physical objects like the houses, buildings, tools, machines, etc. which form part of culture. There are also the attitudes, beliefs, knowledge and skills which form part of culture. But since objects have no meaning apart from the thoughts and actions, it may be asserted that the essence of culture is the attitudes and beliefs transmitted from generation to generation rather than the mere physical objects. We use the terms 'social' and 'cultural' interchangeably. But we can make the distinction clear by saying that society means people and culture means the behaviour of people. We mean by 'society' a particular recognizable, finite body of people; it may be a primitive hunting band, an agricultural village or a modern nation. On

the other hand, we mean by 'culture' the particular way of life of a specific society. The world of human beings is more complex than that of other animals. By mere trial and error learning he cannot survive. Society that makes possible the survival of the individual through infancy also makes necessary the acquisition by him of social adjustments. As the infant grows into the child and then on until the death, society more or less effectively and in various ways, trains him up into social patterns of behaviour necessary for survival under different conditions of social life. A biological heritage determines man's organic potentialities and the social heritage determines his behaviour, attitudes, beliefs and skills. Thus, Sir Edward B. Taylor, who introduced the term and the concept says: "culture or civilization taken in its wide ethnographic sense, is that complex whole which includes knowledge, belief, art, morals, law, customs and any other capabilities and habits acquired by man as a member of society." The differences in culture are due to the differences in social heritage based on varied experiences of different groups.

PRINTING PRESS AND THE SPREAD OF KNOWLEDGE

One of the greatest events in the history of mankind is the invention of printing. Printing was invented in the 15th century in Europe. Chinese were the pioneers in the art of printing. In the history of printing, the first book was printed in China in 968 A. D. Movable type was first used in China in 1301 and a metal type foundry was established there in 1392. Slowly and gradually the art of printing spread in Europe and became popular in fifteenth century. The first book ever to be printed in Europe was the Bible. This brought about a revolution in the publication of books. After this book was printed, many printing presses were established. In the beginning the prices of books were so high that only wealthy ruling class could afford to purchase them.

Communication of knowledge is most significant for the development of culture. Printing greatly enhanced this achievement by making possible economical multiplication of texts on a large scale. Of course, the full possibilities of printing as an agency in the dissemination of knowledge and propaganda were

not immediately grasped either in China or in Europe. But printing played a significant role in economic, social and religious fields.

Moveable type made of earthernware was invented in China between 1041 and 1049. The casting of tin into type followed shortly after and by 1314 a type-setting machine using wooden type was being employed. After that, the type mould and metal type were invented in China. Steam printing was introduced in 1811. Now, it was possible to print 1000 sheets per hour. Afterwards, the rotary press was invented. Rotary press made it possible to print as many as 8000 sheets per hour. With the invention of typesetting machine and linotype, the efficiency was further accelerated and the newspaper printing became possible. Alphabetic type and the printing press, however, were European innovations. Turfan was a great Buddhist printing centre in the thirteenth and fourteenth centuries. Paper money was first printed in China. Cylinder presses were first installed in the pressrooms of the United States in 1882 The modern rotary presses were installed in 1890 and automatic press-feeding attachments in 1899. The installation of automatic feeding attachments and self-feeding job and small cylinder presses has continued rapidly.

The advance in printing would have been of no avail without the corresponding development of new process in the manufacture of paper. In all countries, paper was made by hand. In the year 1798, machine for paper making was invented and this resulted in the fall of the cost of paper. After 1843, wood pulp was used for the manufacture of paper. Thus, the manufacture of cheap paper on the one hand and the possibility of printing thousands of copies per hour on the other hand, made possible the production of books on a large scale. It also made possible the mass circulation of newspapers.

Printing had its impact on traditional communities. For example, for a long time, Islamic world refused to adopt the innovation of printing, especially in reference to the publication of Koran. In India, where the sacred hymns of the Vedas were memorised and transmitted orally, the Brahmins resisted the introduction of printing. The resistance had to give way to public demand. Resistance continued until late in the

sixteenth century. Gradually printing became a fact, and the knowledge which was the monopoly item for a few was disseminated through printing and publishing.

Hellmut Lehmann-Houpt, a historian of book publishing, has pointed out that in America books were somewhat dependent on the more powerful periodicals press; in contrast, this dependence does not exist in Europe, where books have their own traditions. He has found a clue to the different attitudes Europeans and Americans take towards books in different purposes for which printing was originally used in the two continents. In Europe, he says, printing was started in long-established communities as a cheap and easy way of duplicating the accumulated wealth of manuscripts. In America, on the other hand, printing became almost at once an important force in the colonization. The European Press primarily nourished thought; the American press nourished action.

In England, the book-reading public shifted from the upper class to the middle class in the eighteenth century. By the latter half of the century, literacy—and the reading of books—had penetrated to the working class.

The first two recent revolutions in the dissemination of inexpensive books came in 1939, when three publishers succeeded in bringing out paper-back publishing. The second revolution came in the early 1950s, with the introduction of the so-called quality paper-backs. They were costlier than the earlier paper-backs, but their major difference was their appeal to highly educated readers.

With the advent of new methods in printing and publishing, along with books and newspapers, magazines also came into existence. Magazines are of various kinds. There are a mutitude of scientific, religious, artistic, trade, business and manufacturing periodicals. Magazines play an important role in the spreading of knowledge and information; for example, women's magazines play an important role in women's life. According to the study, they are important in three overlapping areas of her existence: Social orientation, realistic concerns, and personal experiences. From stories, articles and advertisements, a woman gets ideas for relating herself to the people in her world and for strengthening her position as the central figure of the

household. She learns how to get along with her own family members and friends. She finds answers to a host of questions raised by her environment: How much her children should watch television? How should she entertain guests, and what should she serve them?

The magazines also teach her how to do all sorts of practical things. They teach her the practical skills of cooking, sewing, and house-keeping. They help her formulate her goals, and also guide her in the attainment of the goals. The magazines also enter into the woman's personal experiences, into her private set of values and judgement. They help her to get rid of the feeling of loneliness. They assure her that the virtues and values she cherishes are the right ones. Same is the case with other magazines.

The application of steam-power to transport by railway and steamship enabled the vast potential output of books, newspapers and magazines to be transported to the millions of readers and the process of dissemination of knowledge was further intensified. To-day, the easy access to books, newspapers and magazines provides the basic material for the increasing growth of literacy. Moreover, because of his changed outlook due to books and magazines, civilized man has become the member of the world community.

MASS MEDIA AND CULTURAL DISSEMINATION

There are material as well as non-material aspects of the culture. There are physical objects like houses, buildings, tools, machines, etc., which constitute the material culture. On the other hand, attitudes, beliefs, knowledge and skills constitute non-material culture. To-day, our socio-cultural systems are changing because of the cultural give and take. When we see merits and advantages in the ways of others, we adopt them as our own. The complexity of our modern civilization is beautifully expressed in Linton's classic passage. He says:

"Our solid American Citizen awakens in a bed built on a pattern which originated in the near East but which was modified in Northern Europe before it was transmitted to America. He throws back covers made from cotton domesticated in India, or linen, domesticated in the Near East, or wool

from sheep also domesticated in the Near East, or silk, the use of which was discovered in China. All of these materials have been spun and woven by process invented in the Near East. He goes to the bathroom, whose fixtures are a mixture of European and American invention. He takes his Pajamas, a garment invented in India, and washes with soap invented in ancient Gauls. He then shaves, a masochistic rite which seems to have been derived from Sumer or ancient Egypt. Returning to the bedroom, he removes his clothes from a chair of Southern European type and proceeds to dress. He puts on garments whose form originally derived from the skin clothing of the nomads of the Asiatic Steppes, puts on shoes made from skin tanned by a process invented in ancient Egypt and cut to a pattern derived from the classical civilizations of the Mediterranean. Before going out for breakfast, he glances through the window, made of glass invented in Egypt, and if it is raining, puts on overshoes made of rubber discovered by the Central American Indians and takes an umbrella invented in Southern Asia.

On his way to breakfast he steps to buy a paper, paying for it with coin, an ancient Lydian invention. At the restaurant a whole new series of borrowed elements confronts him. His plate is made of a form of pottery invented in China. His knife is of steel, an alloy first made in Southern India, his fork a medieval Italian invention, and a spoon, a derivative of a Roman original. He begins breakfast with an orange, from the Mediterranean, a canteloupe from Persia, or perhaps a piece of African water-melon. With this, he has coffee, an Abyssinian plant, with cream and sugar. Both the domestication of cows and the idea of milking them originated in the Near East, while sugar was first made in India. . . ."

It is quite obvious that the very values of judgements by which the contemporary man lives are closely connected with and influenced by the mass media. Mass media have become vital centres that transmit knowledge, disseminate fact and direct the various emotional appeals to influence public opinion. In modern society there are different media being used to influence public opinion and disseminate cultures. The most vital media are (1) the newspaper, (2) broadcasting (radio, television)

media, and (3) film. Let us see how they help dissemination of culture.

NEWSPAPERS

The press is the oldest, the most traditional and the most informative of the mass media. Newspaper has three functions: (1) to provide information about events taking place in the country, and in the world, (2) to offer guidance to understand these events, and (3) to entertain the people.

Prior to the growth of wire service and of radio and television as news-gathering and news-disseminating media, the press meant simply newspapers. Not until the later part of the nineteenth century did the newspaper become a medium of information, advertising, opinion and entertainment. The early newspapers bore only a remote resemblance to the paper of today. They were, in reality pamphlets or newsletters. They were meant for special public, rather than the general public. But, slowly and gradually, they had to cater to the needs of the public at large. Moreover, competing media such as radio and television forced the newspapers to change its form. Newspapers are a very recent growth. The first successful daily appeared in England in 1702 and the newspapers of the modern type appeared in Europe and America in the nineteenth century. Most of the papers of those days published scandals about other people. Gradually, the content of the news changed and in addition of dailies, there were weeklies, fortnightlies, monthlies.

By and large, the press considers news to be a two-faced phenomenon. First, the news is something which attracts the attention of the reader. Second, the news is also something which, once having attracted the attention of the reader, will generate discussion and interest among other members of the social group. Each newspaper takes the same material and displays it according to its own format. A story or a release may be displayed prominently in one paper and omitted or used casually in another not because it is unimportant, but because it simply does not fit in with the formula of presentation.

The content of a newspaper is the material—pictorial or written—which is included in the news, editorial and feature

columns of the paper for reading by public. The content sources are many: happenings or events that make news, press conferences and other newsmaking devices. Apart from the news coverage, the newspaper tends to print partly what the readers want and what the editor deems important material. A function of a newspaper, according to the canons of Journalism of the American Newspaper Publishers Association, is "to communicate to the human race what its members do, feel and think."

A newspaper normally provides a lavish amount of information about local, state and national politics, educational news of schools, colleges and societies, religious news, articles and news about music, drama and new books, social service etc. Sufficient space is devoted to sports. The commercial section gives information about all markets and trades. The Sunday Supplements publish excellent photographic reproductions illustrating specially significant items of interesting occurrences in the country and abroad.

Newspapers not only inform the public, but also try to create and shape public opinion. They write about natural calamities like floods, earthquake and so on. They also write about the social problems such as dowry, untouchability and try to create an opinion against such social evils. Newspapers claim high moral standards and often launch campaigns against social evils. Through such campaigns they try to bring about decency and cleanliness in public life.

Newspaper has advantages over other mass media. Newspaper may be readily used to reach small and specialized audience for which other media would be prohibitively expensive. Newspaper is traditionally associated with culture, and may carry a higher prestige for some people than do the other media. Moreover, a newspaper is believed by some observers to demand a more active, creative participation on the part of the reader than is demanded of the audiences of other media.

In a developing country like ours, the newspapers have a key role to play in disseminating knoweldge and information and shaping public opinion. Newspapers can culturally bring together both urban community and rural community. It is an encouraging sign that there is an increase in the newspapers

in the Indian languages on the one hand and on the other there is increase in the mofussil newspapers.

BROADCASTING MEDIA

Radio and Television —the broadcasting media — are the significant media of mass communication. In terms of impact. radio and television are more powerful media than the press, not only for the purpose of dissemination of news and information, but also for education, advertisement, and entertainment. The radio and to some extent television have overcome the limits of space and time. The radio can carry message to the remotest part of the country and thus can help to reduce a gap between urban community and a rural community. As far as village communities are concerned, radio is the most powerful medium for raising the cultural level of the people and changing their way of life.

The most conspicuous aspect of broadcasting is its rapid growth. In less than half a century, radio and television have superseded other media. The possibility that broadcasting would ever become a medium of information seems to have occurred to a few observers during the early days of radio. Through the years of technical development that followed Marconi's first brief transmission of wireless message in 1895, radio was considered a future competitor with the telegraph. Nonetheless the radio was made an information medium. Radio grew phenomenally during the early 1920s. The development of television which was halted by World War II, came rapidly during the 1940s.

Radio and television offer productive avenue for advertising and publicity. They are capable of informing, entertaining and influencing the thoughts and habits of millions of viewers and listeners. They are powerful agencies of opinion formation and change. Radio as a medium offers phenomenon of pure sound. Television combines sight and sound. Television has made enormous strides and the development of moveable sets has increased the incidence of TV viewing in the home, but radio is still most popular when compared with other media. Radio and television are very powerful agencies for advertising. In the beginning no one had imagined the ability of radio and

television to sell products. Slowly, but surely, the experts recognized that the broadcast media offered vast and deep penetration. They offered a mass market, exposed totally to the public.

Educators also believe that radio and television have been the important educational tools. Talks, programmes for children, and many other programmes on radio and television have an educational value. The children get lessons. Mothers get to know how to take care of the children. Many programmes designed specially for farmers keep the farmers well informed about new methods in agricultural technology. This is especially very significant in the country like ours.

The programmes like 'Science Report' give so much of information about science that changes the whole outlook to life. According to Miss Herzog, people tune in on 'Quiz Shows' because of four major appeals: the competitive, the educational, the self-rating and the sporting. The listener or the viewer can satisfy his competitive image by testing his knowledge against that of the actual contestant. The answers which the viewer or the listener finds in a Quiz prove very interesting as well as useful in every-day conversation.

Radio and television are the effective media in disseminating knowledge and information. Radio in particular is very effective means to give the news-broadcasts, for it reaches the remotest part of the country. Within minutes of an occurrence of any event, the news reaches the remotest part. When the cricket match is being played, millions of people all over the country, are well-informed about the match through radio and television.

FILM

Cinema is one of the important mass media. It has educational as well as entertainment value. The first clear photograph was taken in 1839 in Europe, but so many other inventions had to be made before motion picture became a fact. The first full length motion picture was released in 1903 in the United States. Since that time, film-making has become an industry. The motion picture does not merely represent external objects, but it is capable of expressing the subtler mental

processes far more forcibly than the ordinary photograph. Emotion, feeling and imagination may be interpreted upon the screen by a fleeting glimpse of past events aroused in memory. Thus, by a clever deception of photography the audience is enabled to visualize images that pass through the actor's minds in quick succession and explain his hidden motives, moods, etc.

The people in the industrialised society need some entertainment. Newspaper-reading presupposes some education. Owning of radio, or television set presupposes some standard of living. As such, the newspapers, radio, and television are not accessible to everyone. Under these circumstances, film becomes the cheapest source of entertainment. Apart from mere entertainment, the film has psychological significance. Film takes the viewer in a make-believe world, the viewer identifies himself with the character or characters on the screen and for a time being forgets his routine strenuous life. Film provides a kind of relief from the frustrations of life.

The importance of film as a mass medium and its utility for cultural dissemination has been widely accepted. The motion picture has an important function in the educational field. Historical events, manufacturing processes, biological changes, scientific and laboratory methods are presented very effectively on the screen. X-ray motion pictures show the stomach and muscles performing their function. Slow motion pictures are used for analysis. It is quite evident that from the beginning movies depend largely upon youth for their support. The emphasis on youth is much more stronger today. Movie-makers see to it that they have a youthful audience. They therefore, picturize scenes that the youth likes.

Of course, many films are immoral. They emphasize sex and violence. Sex, crime, fighting and killing, vulgar songs and immodest dances may be the ingredients of the so-called box office, but they corrupt the minds of youth. Film is vastly more appealing and rousing in its effect than the printed words. Moreover, it reaches and excites non-reading classes, illiterates and children. This is the reason why it has become necessary to exercise censorship over films. In many countries censor-boards are established. The mass media are so efficient in dis-

seminating culture and shaping of public opinion that some people fear that the peculiar characteristics of each individual will soon be entirely submerged and lost in the general aspect of the world.

The naturalist, John Burroughs maintains that our separate personalities are likely to be worn down and smothered off by the constant intercommunication and friction of travel, stress, books and newspapers, until we shall become like pebbles upon the same shore, and all alike." But we must remember that this submerging of the characteristics of each individual in the general aspects of the world will bring about harmony and homogeneity in the world.

SUMMARY

Culture is the social heritage of the people. The members of a society quite unconsciously agree on the basic rules for living together. Culture is the short-hand term for those rules that guide the way of life of the individuals. Culture has two aspects: material and non-material.

Printing was invented in the 15th century in Europe. Chinese were the pioneers in the art of printing. The first book ever to be printed in Europe was Bible. With the introduction of steam printing in 1811, it was possible to print 1000 sheets per hour. The rotary press, type setting machine, linotype, automatic press feeding etc. further accelerated the efficiency.

With the advent of new methods in printing and publishing, host of books, magazines and newspapers came into existence. This made possible the spread of knowledge. Now knowledge could reach millions of people through printed words. This brought about radical change in the total outlook of the people.

Socio-cultural systems are changing because of the cultural give and take. When we see the advantages in the ways of others, we adopt them as our own. There is cultural dissemination on a large scale. In this connection, mass media such as newspapers, radio, television and films play an important role.

Newspapers has three functions: (1) to provide information about events taking place in the country, and in the world; (2) to offer guidance to understand those events; and (3) to entertain the people. Newspapers not only inform the people, but also try to create and shape public opinion. They claim high moral standard and often launch campaigns against social evils. Through such campaigns they try to bring about decency and cleanliness in public life.

Radio and television are the broadcasting media. They are the most powerful media of dissemination of knowledge. They have overcome the limits of space and time. Radio in particular can carry message to the remotest part of the country and thus can help to reduce the gap between urban and rural communities. The techniques of advertising and selling, the science of marketing have now taken a new significance with these mass media. Educators also believe that radio and television have been the important educational tools. Programmes for children, women, farmers, workers on radio and television have an educational significance.

Film also is an important mass medium. It has educational as well as entertainment value. The first full-length motion picture was released in 1903 in the United States. Since that time, film-making has become an industry. Apart from mere entertainment, the film also has a psychological significance. Film takes the viewer in a make-believe world. The viewer identifies himself with the characters on the screen and for a time being forgets his routine strenuous life.

The mass media are so effective in disseminating culture that some people go to the extent of saying that the peculiar characteristics of each individual will soon be entirely submerged and lost in the general aspects of the world.

EXERCISES

1. Define culture. How is dissemination of culture possible?
2. State the various stages in the development of printing press.
3. How did the printing technology help spread of knowledge?
4. What role do the mass media play in the dissemination of culture?
5. Write short notes on: (a) Newspaper, (b) Broadcasting media. (c) Film.

Chapter Fourteen

PHILOSOPHICAL AND INTELLECTUAL IMPACT OF SCIENCE AND TECHNOLOGY

Tradition and superstition — Science liberates man from superstition and ignorance — Barriers to change — How to overcome the barriers? Religion and man — Biology and man — Astronomy and man Psychology and man.

TRADITION AND SUPERSTITION

In its literal sense the term tradition means transmission In this sense of transmission, all elements of social life would be traditional. But all the elements of social life are not traditional. Only some of the inherited or transmitted institutions, customs, dress, etc. are traditional. The institution becomes traditional when it is recalled that it existed in the past times and when at least some persons now desire to continue it. What is really a tradition, therefore, is not the institution, but the belief in its value. The term 'Tradere' generally means to transmit. So tradition is that which has been handed down, if not through all generations, at least through more than one. In this sense the traditions are part of the culture of an entire national group.

All existing things have a past. Nothing which happens escapes completely from the grip of the past. Much of what exists is a reproduction of what existed earlier. The need to have a valued past, to be continuous with some aspect of the past, to justify oneself by reference to a connection with the past—are all the marks of a traditional society.

Traditional beliefs are beliefs which contain an attachment to the past, a whole social system or to particular institution which existed in the past. A certain way of acting is regarded as right; a certain order of arrangement is thought desirable.

The maintenance of the tradition is the assertion of this judgment. Beliefs which assert the moral rightness or superiority of institutions or a society of a past and which assert that what is done now or in future should be modelled on the patterns of the past beliefs or conduct are traditional beliefs. Besides, beliefs which assert that an earlier age of one's own society was a 'golden age' are traditional beliefs.

The study of anthropology has made us vividly aware of the mass of irrational beliefs that influence the lives of uncivilized human beings. Illness is attributed to sin, failure of crops to the anger of God. Human sacrifice is thought to promote victory in war and comets are thought to be responsible for bringing disaster. Insanity is thought to be due to the possession by evil spirits. These and many such beliefs are traditional, superstitious beliefs. Superstitions, however, are not a characteristic of traditional societies alone. All nations, the economically backward as well as the developed, have their share of popular superstitions. These superstitions affect human relationships. Of course, all superstitions are not harmful to culture and the growth of civilization. Some of them are indeed harmless and even colourful. They free society from the boredom and monotony of life. But many of the superstitions show an inadequate exposure to the scientific spirit and are positively the hindrance to social progress. The disadvantage of a traditional society is that there is a stagnation at the social level.

The essence of tradition becomes quite clear from the following sayings popular in traditional societies:

(1) Do not attempt to introduce new things; for novelties bring in their train anxieties for those who sponsor.

(2) What is old and known as worth more than something new yet to be understood.

(3) Old is gold.

(4) If we follow the old people, we will not be bitten by the dog.

(6) He who leaves his past, gets lost.

SCIENCE LIBERATES MAN FROM SUPERSTITION AND IGNORANCE

Scientific and technological innovations have shaken the very foundation of traditional society. Scientific outlook vehemently attacked the traditional outlook. As Bertrand Russell says, "there are three ingredients in the scientific outlook of the eighteenth century:

(1) Statements of facts should be based on observation, not on unobserved authority.

(2) The inanimate world is a self-acting, self-perpetuating system, in which all changes conform to natural laws.

(3) The earth is not the centre of the universe, and probably man is not its purpose (if any); moreover, 'purpose' is a concept which is something useless."

The trend of modern, technologically advanced society is to become more democratic. The people in such a society cannot be expected to live a double life as responsible citizens of a democratic state on the one hand and as sheep in an authoritarian church on the other.

As scientific method and scientific knowledge spread among the people, and became a part of life, the result is the weakening of religious beliefs and cultural dogmas. When scientific outlook becomes a part of life, society becomes modern in a real sense of the term 'modern'. Not only the material change but also the intellectual change that is the gift of science and technology. Intellectual modernization leads to a belief in the capacity of the individual to control and direct the course of events in so far as they lie in his power to do so. To be modern is to find oneself at the centre of ever-widening circles of involvement. The more modern a person, the more concerned he becomes with things, which in fact do not appear to touch him personally. He becomes concerned with matters beyond the family, the village and the state. He becomes concerned with matters which touch the whole universe. He becomes the member of the modern world-community.

In the pre-scientific world people believed in the power of God. Famines, cyclones, earthquakes, epidemics, defeat in war, etc., were attributed to the will of God. In the scientific world

all this is different. It is not by prayer and humility that you cause things to go as you wish; but by acquiring knowledge of natural laws. The power that a person acquires in this way is much greater and much more reliable than that formerly supposed to be acquired by prayer.

Alfred North Whitehead rightly remarks that the greatest invention of the industrial era is 'the invention of invention itself'. The industrial era saw many technological innovations. These innovations had their impact on traditional patterns of the society. Even today, the new additions to technological innovations continue to influence society. The most significant aspect of the technological society has been that the introduction of technology has compelled changes in the attitudes and beliefs. Technology sets the tempo of change and necessitates a new attitude towards time itself. This undermines the past beliefs.

The attitude of modern science is infinitely critical of all authorities. The scientific approach has turned upside down the authority of revealed religion and made it unacceptable to modern man. Doctrines can no longer be accepted on trust. They must be sustained by facts, by arguments, and by logical deductions. Dogmatic beliefs could not stand the scrutiny of the scientific method. Galileo declared that there is no human or divine authority which can be placed above experiment and mathematical deduction.

BARRIERS TO CHANGE

The positive attraction of the new and novel seems to be associated with industrial societies. The modern man always craves for the new. Man, through education and opportunity, shares the values of the complex civilization of the West. He is conscious of the utility of the technological innovations such as automobiles, faster aeroplanes, finer buildings, hybrid seed, fertiliser, drugs, computer, etc. He is conscious about the fact that material as well as non-material development of the society is inherent in sciences and technology. He finds it difficult to doubt that the scientific and technological innovations are not good.

It sometimes comes as a surprise, however, to find that many people in technologically less advanced societies are reluctant or unable to accept change. They have strong cultural dogmas. In spite of their desire for new opportunities and new consumer goods, they often do not realize, or are unwilling to accept that the goals they strive for can be achieved only at the cost of old customs and values. The wisdom of tradition still carries weight among many of them. The urge for development and the willingness to change are not equally present in all people. For example, a public health doctor knows he can successfully plan the clinical aspect of a campaign to stamp out small-pox. The problems of the production of vaccine and its storage and transportation to the places where it is needed have long been solved by science and technology. But the doctor does not know how to induce everyone in the village to come forward willingly to be vaccinated. In traditional Indian community, small-pox is thought to be the visitation of Goddess. The remedy lies in rituals, rather than in medical aid. An agricultural expert can analyse soil conditions and prescribe a hybrid seed and modified cultivation practices that will vastly increase production. But he is not sure whether the farmer will give up his traditional method of cultivation. Similarly, an industrialization has brought about changes in the structure of the family and community. It has changed the roles in the famiy. But in traditional family we find the same age-old structure and roles. The relationships among the members, caste and class factors, the authority, the nature of functions, etc. are standardized. These are the cultural and social barriers to change.

We read of a discussion between disciple of Confucious and an old gardener. The gardener was watering his plot, fetching water in a bucket which he carried laboriously up and down the steps fixed into the wall of his well. The Confucian told him of an invention called a draw-well, which made it possible to bring up lots of water very quickly, without much toil. The idea of adopting this easy, effective means moved the gardener to scorn and anger: "where there are wicked inventions, he said, "there are wicked uses, and where there are wicked uses, there are wicked hearts. If one's heart is wicked he has spoiled

the purity of his soul. I know this invention, but I would be ashamed of using it." This is the attitude of a tradition—bound man and a tradition bound society to change. The traditional society is averse to any change.

HOW TO OVERCOME THE BARRIERS?

(1) Traditional societies are hostile towards change. They do not accept the innovations wholeheartedly. But, we must remember that every innovation has its secondary effects. and in many cases because of these secondary effects the innovations do not get ground in traditional societies. The innovation may appear quite logical and desirable to the scientifically trained technical specialist, but some of its consequences may be highly undesirable from the standpoint of the people affected. The people weigh the advantages against possible disadvantages. If the disadvantages are more than the advantages, then naturally they refuse to accept change.

In Indian village, a villager cooks traditionally over an open dung fire in the kitchen. There is no chimney so that the room fills with choking smoke, which gradually filters though the roof. Cooking is unpleasant under such conditions, and respiratory and eye ailments are common. The community development programme recognized this situation as a serious threat to health and developed a smokeless chula. This chula maximises the efficiency of fuel and draws smoke off through a chimney. It is sold at very low cost to villagers. Yet the smokeless chula is not accepted by the villagers. In India wood-boring white ants infest roofs. If they are not destroyed they ruin the roof in a very short time. The continued presence of smoke in the roof destroys the white ants. If smoke is eliminated, roofs must be replaced more often. This expense is greater than villagers are able to support. So the resistance of the villagers to the introduction of smokeless chula is due neither to the villager's love of tradition, nor to his inability to understand the cooking advantages of the chula. He has considered the advantages and disadvantages and found that the disadvantages of the smokeless chula outweigh the advantages. In this case, if the roof can be preserved by other

methods, the resistance of the villager to the improved cooking metnods will be greatly lowered.

(2) When an innovation is introduced, its economic advantages should be quite obvious to the people. As Mair says: "the conservative force of tradition is never proof against the attraction of economic advantage, provided that the advantage is sufficient and is clearly recognized, in the case of land (in Africa). It is abundantly clear that the emotional and religious attitudes toward it which are inculcated by native tradition have not prevented the development of a commercial attitude."

Thus, economic advantage is an important factor in weakening resistance to change.

(3) Where persuasion and demonstration do not succeed. an authority can play a vital role. We know that the potato was introduced into Europe in the year 1776. When potato was brought to Europe, its introduction was vehemently opposed. People believed that potato poisoned the soil and that it was harmful. Benjamin Thompson was then, the Military Adviser to the Duke of Bavaria. He felt that if farmers would plant potatoes, their food problem would be solved. He tried to persuade the people, but all in vain. Finally, as head of the army, he ordered every soldier in the Duke's army to plant potatoes and eat them. Soldiers obeyed the orders. Potato crop appeared all over the country. Gradually people accepted this crop and the food of Europe gained greater security.

(4) People are very sensitive with regard to their traditions. The people in traditional societies may be wrong on technical matters. But until we are sure that they are wrong on a particular point, it is unwise and wrong to try to 'improve' them. One should handle them carefully. The role of a technical specialist here is that of the consultant rather than that of teacher. Read worked in a village of Central Africa. He reports traditional wisdom of an old woman. "You Europeans think that you have everything to teach us. You tell us we eat the wrong food, treat our babies the wrong way, give our sick people the wrong medicine; you are always telling us we are wrong. Yet, if we had always done wrong things, we should all be dead. And, you see we are not."

RELIGION AND MAN

Religion is without question the oldest source of human thought. There have been long periods of time when there was no culture—high culture, i.e.—except what emerged from the religious imagination. Religion is a pervasive and almost universal phenomenon in human societies.

The relation between religion and society is very close. The deepest religious experiences are those connected with birth, marriage, and death. We commonly think of religion as concerned with the supernatural, and it usually is; but the deepest roots of religion lie in this earth, in man's experience of the social and moral community that religion has provided in one shape or another.

There are five elements of the religious community:

(1) **Charisma:** This is the personal nature of religion. In all the great world religions, there was in the beginning the charismatic individual—Moses, Buddha, Jesus, Mohammed, etc. Thus, charisma is the founder of religion.

(2) **The Sacred:** The sacred does not necessarily mean good, pure and holy. Devils, demons and evil spirits are no less sacred in the religious sense than Gods or saints. The sacred draws its nature from all the beings, things, and values beyond the criteria or simple utility or ordinary pragmatic experience. A given religion may lack the belief in God or immorality, but no religion can be said to exist at all where there is no difference between the sacred and the profane.

(3) **Dogma:** Dogma is a proposition held to be true even in the absence of supporting evidence. The essence of dogma is that it is held by its believer to be supreme in and for itself, beyond the ordinary tests of rationality or utility. "God is good". "Killing is evil", "Love of country is right", "Human life is Sacred"—all these are dogmas. Men have sacrificed themselves and exhibited courage and have also killed, tortured and devastated whole lands for dogma.

(4) **Rites:** Religion is composed of rites. Rites are the ways of behaviour that reflect either sacred or the dogma. A rite is a way of behaviour, just as a dogma is a way of belief. Baptism, marriage, etc. are rites.

(5) **The Cult:** The cult is the smallest structure capable of containing the elements of sacred, rites and dogmas. Cult has two aspects: the positive and negative. The negative aspect pertains to those activities within the cult designed to forbid certain activities. The positive aspect of cult consists in symbols and rites through which, in the company of others, the individual maintains directly his relationship to God. Superstition goes with religion and fatalism is closely associated with superstition. In many traditional societies, drought or flood is looked upon as a visitation from Gods or evil spirits. Where medical and social services are lacking, and an individual cannot see any hope, a fatalistic outlook—the assumption that whatever happens is the will of God—is the best adjustment the individual can make. For example, in many non-industrial societies, when an infant dies, the parents say, "it was his destiny not to grow up." On the other hand, when a sick child recovers, the parents say, "see, he recovered without medical aid; God did not intend him to die."

Religious beliefs and sacred texts often contribute to fatalistic attitudes. For example, in a traditional village community in Brazil, a specialist found it difficult to persuade mothers to seek help for their sick children during the month of May. This is because in Catholic teachings May is the "month of Virgin Mary", and in this part of Brazil it is believed that when a child dies in May, it is particularly fortunate since the Virgin is calling her children to come to be with her. To seek medical aid during this time would be to go against the will of virgin. Similarly, an Egyptian physician finds the religious attitude of the people as one of the reasons for high infant mortality in Egypt. In Egypt, death is perceived as Allah's Will, and no one can extend life because the Koran says, 'wherever you are, death will seek you, even if you are in strongly built castles." In India small-pox is classified as a sacred rather than a secular disease. It is the visitation of a Mother Goddess. Consequently, prescribed rituals and worship receive more attention than proper medical care.

Classical religion views man and his adaptation to the environment as Divine purpose; Man is a special creation, it does not give him freedom. On the contrary, it holds that the

human actions are determined. Man is just a puppet in the hands of God. It also believes that a man should subordinate matter to spirit. Let us see now, how the sciences like astronomy, biology and psychology view man and cosmos.

BIOLOGY AND MAN

The theory of evolution by natural selection was the most important single scientific innovation in the nineteenth century. It was a turning point in modern science and philosophy. The adaptations of animals and plants to their environments were a favourite theme of pious naturalists. These adaptations were explained by the Divine Purpose. Before Darwin it was difficult to explain the adaptations of living things to their environment otherwise than by means of the Creator's purposes. Darwin's mechanism of the struggle for existence and the survival of the fittest made it possible to explain these adaptations without bringing in 'purpose'. Darwin established that the creation is not static but changes in time in a way that the physical processes do not. The physical world ten million years ago was the same as it is today, and its laws were the same. But the living world is not the same. For example, the million years ago, there were no human beings to discuss it. It is the evolution which is the real creation of originality and novelty in the universe.

The discoveries of Darwin were thought to show that the evolution of life from its earliest beginnings to its most elaborate product, could be interpreted as the result of the occurrence of small variations in species, reacting to material forces and developing according to ascertained laws. If all offspring resembled their parents, the world would still be populated by amoebas and jellyfish—the earliest forms of life. But we find the variations. So we must suppose that certain creatures there were born offspring that exhibited certain differences from their parents. Further, the food supply is limited and the members of a particular species struggle for it. Those who exhibit a variation of a kind likely to be serviceable in the struggle, will tend to have an advantage over their fellows. In virtue of their superior fitness, they will accordingly tend to survive while their rivals are eliminated. Nature 'selects' those

who are 'fit' to survive in the struggle for existence. Thus, Darwin contended that men are not congenitally equal and evolution proceeds by selecting favourable variation.

Darwin's theory thus eliminated the 'Purpose' from adaptation, and rejected the idea of the biological uniqueness of man. What Darwin did in the general sense was to force the intellectuals to see man as a relation of other animals, as being in nature, as a part of nature. Darwin's theory had its considerable impact on the religious orthodoxy.

ASTRONOMY AND MAN

The subject of astronomy is thought important in all cultures. Astronomy is the knowledge that guides us through the cycle of seasons—for example, by the apparent movement of the sun. In this way, there can be fixed time when men should plant, should harvest and so on. Therefore, all settled cultures have a calendar to guide their plans. Of course, the astronomy does not stop at calendar. There is also another use among early people. The movement of the stars in the night sky can also guide traveller, and particularly the traveller at sea who has no other landmark. The universe is vast and the stars in it are innumerable. Sir James Jeans estimates "The probable number of stars in the universe is probably something like the total number of grains of sands on all the sea-shore of the world."

The conflict between science and religion first became explicit in the debate over the tentative hypothesis advanced by Copernicus in 1543, which placed the Sun rather than the earth in the centre of the universe. This was condemned by leaders of all the churches. These leaders strongly believed that God created the earth as superior to all planets and stars. and therefore, it occupied the central position.

The works of Galileo, Newton and Descrates made possible the scientific comprehension of nature. Theological conceptions of nature were overthrown. Mathematics aided by the methods of observations, experiments and intuition became the tool of investigation. Galileo attempted to cover all the phenomena of physics within a single system of laws. He unified the principles of the earth and heavenly bodies by the law of inertia.

Before Galileo it was thought that a lifeless body will not move of itself, and if it is in motion it will gradually come to rest. Only living beings could move without the help of some external agency. Aristotle thought that the heavenly bodies were moved by God. On earth, animals can set themselves into motion and cause motion in dead matter. Galileo proved that all the movements of the planets and of dead matter on the earth, proceed according to the laws of physics, and once started will continue idefinitely. This did away with the unmoved mover (God) of Aristotle.

Galileo also invented powerful telescopes. With his telescopes, he explored the sky. He discovered sunspots, mountains on the moon and Jupiter's satellites and said that the milky way was a myriad of millions of stars. When Galileo's telescope showed Jupiter's satellites, the religious authorities refused to look through it. They believed that there could be no such bodies and, therefore, the telescope must be defective. But the world had to accept the observations made by Galileo. Galileo's approach to problems changed the very outlook of people. The importance of the method of observation in proving or disproving any proposition was recognised.

Newton conceived the idea of universal gravitation, and tested it by calculating the motion of the moon round the earth. The moon was a powerful symbol to him. If she follows her orbit because the earth attracts her, he reasoned, then the moon is like a ball that has been thrown very hard. She is falling toward the earth, but is going so fast that she constantly misses it—she keeps on going round because the earth is round. Newton gave a system relating mass to momentum and force. He was of the opinion that the material world consisted of a collection of particles either at rest or in motion through the space, and a body suffered no change in its state unless acted upon by a force.

The Astronomy in the seventeenth century had its impact on the view of man. For example, Dante in his Divine Comedy had thought of the universe as ten concentric spheres revolving round the earth. The good people after death enjoy eternal bliss in one of these spheres and the bad ones are punished at the centre of the earth. Astronomical findings of Copernicus,

Galileo and Newton disproved this picture of the universe. Similarly, in the pre-scientific period all powers belonged to God alone. Every phenomenon in the world was attributed to the will of God. It was thought that a man is just a machine in the hands of God and that he was powerless. Findings of Galileo shifted power from God to man.

PSYCHOLOGY AND MAN

Modern psychology in general, and psycho-analysis in particular had its impact on the intellectual trends. Psycho-analysis is a school of psychology, headed by Freud. This school emphasizes the dynamic psychic determinants of human behaviour. According to Freud, mind consists of three levels: the conscious, the preconscious and the unconscious. Mental events and memories that the person is aware of at the moment constitute the conscious mind. The preconscious is the store-house of surface memories and desires that are not conscious at the moment but are recallable. The unconscious is the store-house of repressed thoughts, emotions and impulses that are not readily accessible. The contents of the conscious and the preconscious mind are internally consistent, temporally arranged and adaptable to external events. The unconscious on the other hand is timeless, chaotic and primitive. The unconscious mind consists of thoughts, wishes, memories that have been repressed or pushed back into the store-house of the mind because they were too shocking, painful or shameful to tolerate. The unconscious material is denied direct access to our conscious awareness because it would offend our finer sensibilities. 'The unconscious' is not only the larger, but also the more important part. The human personality is like an iceberg, only a small part appears above the level of consciousness and the remaining larger portion is below into the 'unconscious'. The unconscious is not dormant. Like the muddy undercurrents of a deep river, it exerts a profound effect on the composition and flow of the clearer matters above. Dreams, inner conflicts, slips of tongue, neurotic symptoms are the results of the unconscious. The unconscious is a buried trouble. To explore the materials of the unconscious is the main objective of psycho-analysis.

Freud divides the personality into three parts: The Id, the superego and the Ego. The Id is the representative of the unconscious. Its only objectives are the pursuit of pleasure and the avoidance of pain. This part corresponds to the popular conception of the beast in man. Since it is the representative of the unconscious, like unconscious, it is chaotic, timeless and out of contact with reality. It is devoid of social and ethical values. The super-ego corresponds to the popular conception of 'conscience'. It consists of inherited moral sense that has been intensified and modified by culturally acquired restraints. and ideals. The Ego is the 'I' that thinks, feels and wills. The main functions of the Ego are (1) to satisfy the nutritional needs of the body and protect it against injury, (2) to adjust the wishes of the Id to the demands of reality, (3) to enforce repression, and (4) to co-ordinate the conflicting strivings of the Id and the super-ego. The Id is the energy source of the Ego, and the super-ego is the moral censor of the Ego. Freud's psychology results in 'determination' and 'irrationalism'.

Determinism

As we have seen, Freud holds that the unconscious is a larger portion of our mind. Our conscious thoughts and events also depend upon the unconscious. In fact, conscious events are merely the smoke and flame given off by the unconscious. Our thoughts and actions have their roots in the unconscious. Our thoughts determine what we think and our desires determine what we do. This is the element of determinism in Freud's psychology. But this determinism is self-determinism. According to this theory, the individual is determined, not by natural forces, nor by an external environment nor by the will of God. The individual is determined by himself. He is determined by the forces and tendencies operating within himself. The tendencies and impulses which were originally his on the first occasion on which he acted are those which really determine the whole subsequent actions. The psycho-analysis represents a man not as drawn from in front by as pushed from behind.

Irrationalism

Freud firmly believed that the forces that dominate our thoughts and actions are fundamentally instinctive and therefore non-material in character. The unconscious is a restless ocean of instincts and impulses. The driving force is the unconscious and the consciousness is a sort of by-product of the unconscious. Reason has no place. In fact, reason is the handmaid of instincts. Reason is a mere tool for reaching these conclusions to which our instincts prompt us. The beliefs we hold are not the result of an impartial survey of the evidence. but are the reflections of the fundamental desires and tendencies of our nature. We believe whatever our instincts dictate and then with the help of reason find arguments in support of our belief.

Much of importance was traditionally attached to reason But psycho-analysis belittles reason. This attitude of psycho-analysis to reason is to a great extent responsible for the scepticism in modern thought. Psycho-analysis has overthrown the authority of reason. Further, psycho-analysis shows that the desire to exercise power over others is one of the fundamental drives of the unconscious. Man tries to justify and rationalize this authority through the expressions 'Parental authority', 'the divine right of the King', 'the holy will of the clergy', and so on. But the fact is that a man wants to impose his will on others. Freud has exposed the psychological basis of authority. This psychological explanation of authority is responsible for the general distrust of authority in the modern time. In modern times, man questions authority not only of the priest and king, but also of the self-constituted experts and scientists. Thus we find that psycho-analysis played an important role in moulding intellectual trends.

SUMMARY

Tradition means transmission. So tradition is that which is handed down, if not through all generations, at least through more than one. Traditional beliefs contain an attachment to past. Superstition is the mark of traditional society. Traditional society is averse to any change.

As scientific method spreads among the people, and becomes a part of life, the traditional beliefs, superstitions are weakened. According to Russell, the ingredients of scientific outlook of the eighteenth

century are: (1) statement of fact should be based on observation, not on unobserved authority; (2) the inanimate world is a self-acting, self-perpetuating system, in which all changes conform to natural laws, and (3) the earth is not the centre of the universe, and probably man is not its purpose. Science with its methods and innovations liberates man from ignorance and superstition.

Man craves for the new. But in technologically less advanced societies we find that the people are reluctant or unable to change. Traditional notions constitute the barriers to change. How to overcome these barriers is a problem. We can help people overcome these barriers by: (1) seeing whether there are any secondary effects of innovation. If there are secondary effects, we should try to eliminate them, (2) making the people aware of the advantages of innovations, (3) exerting a kind of authority, and (4) trying to introduce changes without adversely affecting the traditional wisdom of the people.

Religion has five important elements: (1) Charisma; (2) The Sacred; (3) Dogma, (4) Rites, and (5) Cuits. Superstition goes with religion and fatalism is associated with superstition. May is the month of Virgin Mary, smallpox is the visitation of Mother Goddess, whatever happens is the will of God — is a fatalistic attitude. Classical religion views man as a special creation, and his adaptation to the environment as 'divine purpose'. However, the sciences of biology, astronomy and psychology view man quite differently.

Darwin's mechanism of the struggle for existence and the survival of the fittest made it possible to explain the adaptation of man to his environment without bringing in 'purpose'. According to Darwin man is not a special creation. Man is evolved from other animals. Findings of Galileo and Newton shifted power from God to man. Psycho-analysis of Freud resulted in determinism and irrationalism. According to Freud, man is the architect of his personality. He is determined from within and not from without. This is the intellectual impact of science.

EXERCISES

1. What is tradition? Does it constitute barriers to social change?
2. What are the barriers to change? How to overcome these barriers?
3. Enumerate the essential elements of a religious community.
4. What is the classical religious view of man?
5. Explain the conflict between Astronomy and Religion.
6. How does Darwin explain the adaptation of human being to his environment?
7. How does psycho-analysis explain the human behaviour?
8. How does psycho-analysis differ from religion in its view of man?
9. Does science liberate man from superstition and ignorance?
10. What is the intellectual impact of science?

Chapter Fifteen

MODERNIZATION AND INDIAN SOCIETY

Modern and modernity — Modernization — The role of intellectuals — Moral and religious aspects of Modernization — Ethos of technological Society — Pre-industrial features of rural India — Impact of Economic and technological forces — Pre-industrial values and city culture — Characteristics of industrial Society — Impact of industrialization and modernization — Evaluation

In this chapter, we shall consider the impact of science, technology and modernization on Indian Society. The concepts of science and technology have been explained in Chapter 1 and hence these concepts have not been specifically mentioned. Moreover, there is a genuine problem of clarifying the concept of modernization. There is vast literature on the use of this term and hence detailed discussion is out of the scope of this book. As we are primarily concerned with its impact on Indian society, we will accept definition which is most appropriate to our purpose rather than indulging into endless discussion on it.

MODERN AND MODERNITY

The terms 'modern', 'modernity' and 'modernization' have been often used wrongly because these terms at the first instant seem innocent, straightforward and simple but in fact they are complex, vague and hence often misused. It is, therefore, necessary to give some hints as to what these terms do not mean, before we accept the positive definitions.

Everything that is modern, is not necessarily good; for example, industrialization may be good for mass production but the industrial urban slums, a relatively modern development is neither good nor desirable. Similarly, everything that is recent, is not modern because a recent fact may tend to retrogression as in case of the recent phenomenon of working

for monetary gains rather than for a joy and pride. Sometimes, modernity is a threat or a horrifying phenomenon, for example, bacteriological warfare or nuclear weapons are threats, although they are modern. The term modernization has also been used as synonymous with westernization or urbanization or evolution or development. But for the reasons mentioned above, we cannot accept these terms as equivalent with the term modernization.

According to Wilfred Smith, "The term modern-is not something which is to be 'adopted'. It is something to participate in; not to have, but to do and to be. And not even to be, but to keep becoming—a process, an orientation, a dynamic." He says. "Modernity in the world at large is a process of rendering feasible the gradual transformation of human life from what it has been into what we choose to make it. Our awareness that this is so, our choosing that we will strive for one thing rather than another and our ability to implement our decision technically—these are the measures of our being modern."

MODERNIZATION

The term modernization, if it is used indiscriminately may lead to misconception of the processes of change that are taking place in human societies. We must remember that we have to use it to understand its impact on Indian society. It would be appropriate to define it in the word of Wilfred Smith who was invited by "The Indian Council of World Affairs" to give lectures on 'Modernization of a Traditional Society.'

According to Wilfred Smith, "Modernization is that process by which this country (India) becomes conscious of itself and of its processes and of the kind of country that is possible for it to become, and by which it finds or constructs the technical means for executing such choices as it consciously or unconsciously makes."

The above definition of modernization implies that in order to be modern (a) men should be aware of the situation in which they stand; (b) they should also be aware of the processes in which they are participants; (c) their awareness of the possibilities of becoming is also important, particularly because of

the development of science and technology and (d) men should choose deliberately among those various possibilities i.e., they should actively pursue their freely selected goal. In other words, to be increasingly conscious, and to act in the light of that consciousness, constitutes a person or a society as modern. Ignorance is a bar to being modern. The term modernization has been widely used in the economic sense in the twentieth century. But our stand is that modernization does not start with economics or technology; on the contrary it starts with man's moral awareness and intelligence. However, it does not deny that economic prosperity and use of technology constitute some ingredients among many others in a subtle complex. Economic prosperity is rather a symptom than a cause of modernization. But no one will dispute that the modernization of India involves eventually a raising of living standards in the economic sense of the term. It is important to note that to give primacy to economics and to technology is wrong. Choosing in the sense of actively pursuing economic prosperity is the consequence of having become modern rather than the precondition of modernity.

THE ROLE OF INTELLECTUALS

The process of modernization is a dialectical process because in it intellectual awareness and scientific and technological construction proceed side by side, intertwining and each furthering the other. For the sure and rapid success of this process, it must be recognised that fundamentally intellectual and moral awareness is primary, economics and technology are secondary and subordinate. The ideas that intellectuals have held and hold are the first consequential factor in determining the direction and the speed of that progress. Before doing something one must know what is possible to do and to be worth doing. This is the first step in social transformation.

The idea that economics and technology are primary to progress is inadequate. It fails to see other factors which are crucial. The economic ideas of planners, the engineering ideas of constructors, the industrial and mechanical ideas of managers and workers are significant, but beyond all these ideas is the massive and decisive influence of the general ideology of all

these men. It proceeds on the assumption based on the total. attiude to the world, to work, to one's neighbour, to human destiny, to history and to God. The ideology based on these assumptions influences behaviour at every level, from economic planning to the society's orientation to the whole enterprise. It is the construct of the intellectuals as a group that is crucial in determining both the general shape of modernization and its speed. It would be wrong to create material situation and to follow the ideology emerging out of that situation. On the contrary, we should proceed on the basis of the ideology and create the material situation, accordingly. This is required to be done by intellectuals.

The intellectuals of any society are by definition those who formulate and nourish that society's ideology, who are custodians and extrapolators of its dominant ideas and values. They are responsible for the most profound determination of the society's development. For example, the decisions to industrialise India after 1947, injecting the concept of economic planning, the whole apparatus of deliberate social transformation; these had been first of all decisions in the minds of intellectuals before they were implemented. The economic and technological conditions of India in 1947 had nothing inherent in them for taking these decisions. On the contrary, the 'backwardness' of this country led to the idea of a transformation by industrialization or by other policies. Logically, economics is a necessary condition of socio-cultural creativity but not a sufficient condition of it. We have, therefore, to be aware of the role of economic and of other factors such as moral, religious, artistic, political, technical, etc.

MORAL AND RELIGIOUS ASPECTS OF MODERNIZATION

To transform a country like India from its present condition into one of prosperity, health and social harmony is a large task. Prosperity is not automatic; it requires vision and drive. To have vision to choose among the various possibilities is a moral question. The question of drive has traditionally been a religious one. So, the transformation of society is a question with moral and religious implication. What men think, feel and choose and with what quality they act, are religious ques-

tions. For example, when people are made aware of the problem of population growth, the 'awareness' of the people will enable them to choose to postpone marriage for some time or the 'modern' couples will choose the number of children that they will have. This awareness is a moral choice. The fact of restricting the number of children when told at the time of conventional blessings by a Brahmin at weddings, would mean religious involvement of this problem. Another fine example is that of the role played by Mahatma Gandhi in transforming the society. He presented his programme in terms related to the traditional culture of India and so it was seen and felt by the masses to have religious and moral involvement. But he did not succeed in relating Industrialization to religious and moral values because he saw only evils of technological society. On the contrary, for the late Mr. Jawaharlal Nehru, the then Prime Minister of India, industrialization was a moral issue because for him Industrialized India was good. It is true that without appropriate morality and faith no venture succeeds. They are relevant to the economic progress and are part of modernization.

ETHOS OF TECHNOLOGICAL SOCIETY

In the above examples we have seen how moral choice made by the intellectuals is related with the economic progress of the society. As intellectuals in current political framework have to yield to the many pressures, they are not free to make a choice by which society would be benefited to a large extent. The intellectuals are not enjoying the full freedom to make a choice and so when the choice is made, it is made with the awareness that certain good as well as evil consequence are bound to follow. But the intellectuals are helpless in this matter. Unless the whole society is morally aware, we cannot expect only 'good' out of the policies formulated by the intellectuals. But it is the duty of the intellectuals to give proper policy and direction to the country. If they fail to do so, there will be adverse effect on society's economic prosperity and value system. The question of what is good and what is bad or evil is a moral question. This question is often discussed while considering the nature of a technological society.

The term 'ethos' has been used in the sense of customary behaviour or morals. When we talk of the ethos of technological society, we think of 'good' or 'evil' of a society which is largely influenced by the technology. Is a technological society good? Has it produced more evils than good? These are the questions which we have to answer before we think of modernization of Indian society. This will enable us to follow the policy framed by the intellectuals in its spirit and deeds. The rapid and various kinds of mass production of a technological society leads to materialistic approach to life and results into the loss of faith in the spiritual values. In a technological society man becomes the slave of machine, and this dehumanization makes him to treat everything as means for his personal happiness. It is, however, doubtful whether a man really knows what happiness is. On the contrary, the superficial means of happiness does not satisfy him and he becomes restless and tries to struggle for the peace of mind which he fails to get. Today in a technological society man suffers from various types of mental diseases, in fact, the whole society suffers from two major neurosis: anxiety and fear of insecurity. Since the industrial revolution, the working hours of many have been considerably reduced but man does not know what to do in his leisure time, so boredom is another mental illness from which the society suffers. Unless man pursues spiritual values and lives a moral life, he would never be satisfied. The purpose of technological society is good because it is helping to increase productivity and remove poverty. It has helped man to save his energy from the laborious work. It has brought down the physical distance but there is alienation. It has increased the means of communication, but there is no real communication between a man and a man and between a man and God. It has spread rationalism, but it has failed to take 'irrational' to the transcendental level which makes man miserable. So we cannot say that a technological society is wholly good or bad.

PRE-INDUSTRIAL FEATURES OF RURAL INDIA

Traditional society in India shared many of the characteristics of other advanced societies, especially in respect of its pre-industrial features. It would not be an exaggeration to

state that Indian society was more advanced, in so far as some of the handicrafts reached technical and aesthetic perfection. Of course, there was no standardized output on a large scale basis. Similarly, no investment was made on production raising inventions. The people in pre-industrial era were content with whatever was available to them. This was pathetic. The contemporary Indian society is also called pre-industrial society because the process of industrialization is not yet complete. Although some rural areas have been affected by industrialization, by and large, rural areas of the modern times are not entirely different from the traditional societies existing before the industrial revolution.

The Indian village in the past was more than a collection of individuals. It was closely knit and well integrated society. It was based on caste system and division of labour. It was functioning on the basis of self-regulation and self-government. The leadership was based on status which carried with it a code of obligation and duty. Village opinion was usually powerful enough to ensure good 'government'. Even then we cannot confidently say that every village was self-sufficient in the rigid sense of the term.

There were transactions between neighbouring villages and villagers sent out their commodities to wider markets. Fairs, weekly markets and peripatetic traders and artisans formed a link between villages and towns. Villages were dependent on urban areas for certain specialised services, especially in construction work. Taxation also provided a link between villages and the outside world. With all this, the villages and village system continued more or less in tact over the centuries. In fact, there was greater cultural unity even when the bullock cart was the only transport.

IMPACT OF ECONOMIC & TECHNOLOGICAL FORCES

To evaluate the impact of modern economic and technological forces on rural society and culture we will have to study the changes undergone by the rural-urban nexus. Modern technology is effecting a basic change in this nexus. Not many factories have so far been established in rural areas; nor has agriculture been mechanised to any considerable extent. But

the institutions and culture in villages have been changing rapidly for several decades.

It is interesting to note that although the industries are growing in India, the number of people dependent on agriculture is increasing. So the pressure of population on land has been increasing. This is one of the results of change in the rural-urban relationship. Before the impact of modern socio-economic forces, Indian villages were marked by a balance between agriculture and industry. There was no compelling inclination on the part of pre-industrial city to sell its goods to villages. With the growth of industrialization, urban centres in India became the supply centres of factory made goods. For the existence and growth of trade and industry in urban centres, a growing demand for these goods in rural areas was vital. So the urban centres turned rural areas into true colonies. Villages were expected to supply raw materials and labour to urban centres and provide an ever increasing market for the goods of mass production. So there was basic change in the economic relationship between urban centres and rural India. The village industries began to decline due to their inability to face the competition from cheap factory made good. Consequently, a large number of village craftsmen had to give up their traditional occupation and to shift to agriculture. In other words, the villages were deindustrialised. This change resulted into the decline of traditional cottage industry and also that of agriculture in the villages. The occupational structure in rural areas underwent a radical change and many traditional crafts began to languish. This affected not only economy, but also the aesthetic aspect of village life. The great depression of 1929-31 broke the backbone of many village households by bringing down the price of agricultural products to an extremely low level. The weakening of the subsistence character of rural economy has a profound influence on the whole way of life.

PRE-INDUSTRIAL VALUES AND CITY CULTURE

In the traditional village economy of India, utility and not profit was the directing principle of production. An agriculturist household would get throughout the year the services of

castes and craftsman such as Nai, the Dhobi, the Potter, the Carpenter and the Ironsmith. These latter in their turn would get a traditionally fixed part of the products of agriculture from the former at the time of harvest or during the festivals. This relationship was based on reciprocity but neither work nor economic decisions were dictated by market forces. The division of labour was predominantly traditional. It was not governed by competition. Similarly distribution was not governed by market mechanism.

The subsistence character of economy had deep implications for the pattern of social relationships and values. Co-operation and contentment rather than competition and unlimited acquisition marked the rural society. The emphasis of mass product is on marketability rather than on use and beauty. In acquisitive industrial societies, work gets alienated from life, utility is divorced from aesthetic considerations. In traditional societies, artist was not a special kind of man, but every man was a special kind of artist.

With the decline of subsistence economy, money and profit are becoming more and more important as determinants of behaviour. The farmer is increasingly conscious of market. In many areas there is understandably a swing in favour of cash crops. The incursion of machine made products and modern attractions like cinema enhance thirst for cash. The increasing power of money in rural life often makes the villager more susceptible to exploitation by the money-lender. Emigration from rural areas has been a very potent level of socio-cultural change in recent decades. In India, the people who go out of rural areas are actually pushed out from there because of the dire necessity rather than being pulled by the attraction of city life.

Agriculture is a hazardous occupation in India. Failure of crops due to drought or flood is a common event. In such an eventuality the villager is forced to leave the village in search of some employment in the city. Similarly, when the debt to the money-lender becomes too heavy or a bullock dies, the villager has to go out in search of money. A villager wishes to return to the village as early as possible. Even while the emigrant lives in the industrial city, his outlook remains exclu-

sively rural. He is not motivated to become an integral part of the urban proletariat. He leaves behind other members of his family. So he becomes a living channel of communication between the modern urban centre and his village. During his visit to village he unknowingly introduces many material and non-material elements of modern culture in the village.

After the British impact, the culture and ideas in town began to be transferred. A new world view is based essentially on western ideas of individualism, competition and activism to gain ground in urban centres. As these ideas make intrusion in the village through the modern type of education and modern means of communication, the very existence of the culture of the folk appears to be threatened. Dut to the spread of modern formal education in rural areas, the old balance of power in community seems to be threatened. The authority was challenged In many ways, cultural and ideological elements seem to be threatening the very existence of rural culture. According to Prof. Norman Brown, "Indian society presented a unique quality of tolerance, a tolerance of the new, the unusual and the different, a capacity to reshape itself in changing conditions, a quickness of comprehension and a willingness to seek for new solutions to new problems. But this tolerance was inhibitive of a spirit of revolt and change and it gave outdated and reactionary social institutions and customs and stability that is now causing difficulties in effecting the transition to a scientific and industrial society. The changelessness in Indian society extended itself through the period of the industrial revolution and beyond it. For the success of British rule over India, this was a good situation because the prolongation of the traditional society facilitated the rulers to exploit Indians. It is one of the causes why there is delay in transformation of the pre-industrial society of India into a modern, scientific and industrial society. With the advent of independence, India started on the march towards industrial society."

CHARACTERISTICS OF INDUSTRIAL SOCIETY

We may enumerate the following characteristics of Industrial Society to enable us to evaluate ourselves whether Indian

society is really an industrial society. We will also be able to judge whether there is enough modernization of India. The characteristics of industrialised society are: (a) Increase in productivity, (b) Substantial increase in output of goods and services, (c) Noticeable rise in the per capita income of the people and their levels of living, (d) there is a revolutionary change in the pattern of occupation and employment, (e) there is substantial rise in the employment in indueries, (f) machinery and power are crucial additions to the production system, (g) there is complete transformation of productive process, (h) economy gets market oriented, (i) the market gets enlarged dimensions, (j) the economy passes from self-sufficiency to interdependence, (k) production becomes cost conscious and takes the form of purposive and economic activity.

IMPACT OF INDUSTRIALIZATION AND MODERNIZATION

Contemporary Indian society is a developing society. It has its deep-rooted traditions but also wants to become 'modern'. There are some who prefer traditional ways of life, some prefer modern society and still some people prefer synthesis between traditionalism and modernity. A traditional system may accept and absorb modernization upto a certain point or a modernized system can tolerate traditional values upto a certain degree. But this co-existence cannot last long. A time will come when the traditional ethos and technological ideas become irreconcilable. It must be admitted that tradition and economic growth cannot co-exist.

The contemporary Indian society is affected by the consequences of industrialization which follows normally everywhere. It is true that today in the Indian society there is breakdown of the family system, disruption of prevailing class structure, disintegration of status and role arrangement prevailing in the traditional societies, weakening of established system of authority, transformation of traditional tastes and gradual erosion of established values. The nature of contemporary Indian society and the effects of industrialization on it, give rise to the idea of how modernization should take place and to evaluate whether intellectuals have succeeded in modernizing India.

EMANCIPATION OF WOMEN

Women are generally considered responsible for the maintenance of home life and the care of children. But in spite of the rise in the number of women going outside the home to work, the full implications of an appalling double burden for millions of women have not been grasped by our society. Women workers are paid less than men. They are neither promoted as much as men nor are they to be found in great numbers in the professions and in management jobs. Any legislation to improve this lot of women will not be successful unless women are able to escape from the low paid and unskilled jobs. Moreover, there should be radical change in relationships between, and roles of men and women both at home and at the work.

It was believed for many centuries that wife's duties to her husband are to serve him in subjection, to be modest in speech and apparel, to have charge of the house and its management. Before the industrial revolution, women were one-half of an economic unit. The division of labour in the home was then unknown. Home and work were inextricably linked. Real life was domestic. There were of course, the wage earners, the families of the landless farm labourers, whose lives were affected by poverty. The suffering of the women were acute, often. She was half-starved. The children of the labouring poor, and single women, often became servants in rich homes. It was the advent of modern technology that did away with slavery, raised the status of women and children, made social welfare a reality and put freedom from hunger and insecurity within every one's reach. The demand for labour in the manufacturing service industries has greatly increased. Similarly the people have felt the necessity of two income to support a home. Due to the spread of education and the creation of new jobs specially meant for women in the industrial areas, women have started earning independently. This economic independence has freed them from the unnecessary drudgery at the home. In modern times, in the industrial towns, they have started asserting themselves on variety of issues such as political, economic, educational, cultural, social and valuational. The modern technology has emancipated women in certain respect but

both men and women cannot escape from the evils of the technology and industrialization. We can only say that the women are in better condition of living in modern society than the conditions prevailing in the primitive societies. [For further details on this issue please refer to the chapter on social change].

The intellectuals in India make attempt to build a superstructure of modernization on the plinth of traditional values and world view. The objectives, targets, and goals belonging to the category of modernization such as planned economic growth, socialism and democracy have been set but the institutional agencies to implement them have not been sufficiently modernized. It is therefore necessary to inculcate a temper of science and a redefinition of the need-goal-role relationship in the contemporary society. Better functional institutions are needed to this job. The existing organizational framework is hardly suitable for growth and change. Moreover, considerable inputs are required for communication, education and population control. Top priority should be given to these human resources to accept the challenges of change. Similarly, overall transformation of attitudes, norms and values has to be aimed at in order to create the following conditions: (a) willingness to take bold decisions and risks, (b) a high level of aspiration and achievement motivation, (c) a national interest, (d) an open society and mobile personality, (e) development of a rational and scientific outlook towards life, and (f) reorientation towards economic development.

EVALUATION

It is true that although the policy makers have tried to modernize India for last thirty-one years, the attempts at modernization are not successful. The visible proof of this is the poverty in India. For example, a sizeable percentage of people live below the poverty-line in India. The gulf between the rich and the poor has widened. This is a serious thing because it would inevitably undermine the democratic foundations of the economy. There is need to provide non-farm employment in the rural and semi-rural areas to restrain congestion, breakdown of city life and the growth of crime and violence. Simi-

larly, the need to bring agricultural technology on a wide enough basis has not been satisfied as yet, which is the major issue affecting the largest section of the people. Agriculture and rural development must be at the core of public policy. Similarly, we need scientists and technologists for choosing and evaluating new technologies borrowed from other countries or develop these technologies indigenously. The large industries in public sector have imported plants and have not thought of further development and expansion. Jawaharlal Nehru once said, "Operating a steel plant or a chemical plant set up by foreign assistance hardly makes the country an advanced and industrialised nation." All three steel plants set up so far have been dependent on foreign collaboration without a strong cell for designing and building, technical self-reliance and self-generating process. Development work in terms of inputs and outputs has been disproportionate. There is a tremendous lag between investment of money and men on one hand and the results on the other hand. In short, unless the policy-makers take into account all the preconditions of modernization and frame their policies accordingly, the process of modernization will be delayed and make the existing problems more difficult to solve.

SUMMARY

The terms 'modern', 'modernity' and 'modernization' are complex, vague and often misused. To be modern is to keep becoming — a process orientation, a dynamic. Modernisation is a process of rendering feasible the gradual transformation of human life into what we choose to make it. Modernization is a process which starts with man's moral awareness and intelligence. In this process men choose the possibility of becoming, i.e., they actively pursue their freely selected goal.

Modernization does not start with economics or technology. It starts with man's moral awareness and intelligence. To give primacy to economics and technology is wrong. The process of modernization is a dialectical process because in it intellectual awareness and scientific and technological construction proceed side by side, inter-wining and each furthering the other. The ideas of intellectuals determine the direction and the speed of the ideology of the intellectuals is crucial in determining both the general shape of modernization and its speed. By intellectuals we mean those who formulate and nourish the society's ideology and who are custodians and extrapolators of its dominant ideas and values.

Prosperity of any society depends on vision and drive. To have vision to choose among the various possibilities is a moral question. The question of drive has traditionally been a religious one. The transformation of society depends on moral and religious implication. What men think, feel and choose and with what quality they act, are religious questions.

The question of what is good and what is bad or evil is a moral question. It is discussed while considering the technological society. This is the question regarding 'ethos' or morals of technological society. the nature of technological society is such that we find certain things advantageous and certain things disrupting the whole way of life. In solving a problem by technology, some other problems are created. So, we cannot say that technological society is wholly good or wholly bad.

The rural India before the industrial revolution was a closely knit and well integrated society, but it may not be self-sufficient. However, there was cultural unity in India. The economic and technological forces have effected basic change in the rural-urban nexus. Pre-industrial values and city-culture have been changed in many respects. The city culture has influence over the pre-industrial values.

To understand the impact of industrialization, on contemporary Indian society, it is necessary to know various characteristics of idustrial society. The contemporary Indian society is a developing society, but it has certain deep rooted traditions and hence we find different trends to look at the industrialization. The Indian society has been affected by industrialization in the same way as the other societies have been affected. The nature of the contemporary Indian society gives us idea of how modernization should take place, and to evaluate the process of modernization of the Indian society.

We cannot forget the fact that the intellectuals of India have to build a superstructure of modernization on the plinth of traditional values and world view. This fact is important to evaluate the role of intellectuals in modernizing the Indian society. Certain objectives, targets and goals such as planned economic growth, socialism, democracy have been set but not implemented properly. The traditional institutions through which modernization is being done, delay the process of modernization. Certain measures are suggested for the success of the process of modernization. However, what we notice today is that modernization is not yet successful. The visible proofs of this is the poverty in India, the gulf between the rich and the poor, etc. Unless the policy makers take into account all the pre-conditions of modernization, and frame the policies accordingly, the process of modernization will be delayed.

EXERCISES

1. Explain the terms 'Mordern', 'Modernity' and 'Mordernization'.
2. What is the role of intellectuals in the process of modernization?

3. What are the moral and religious aspects of modernization?

4. Is a technological society good? Discuss this question in the light of the ethos of a technological society.

5. What are the features of pre-industrial rural India?

6. What is the impact of economic and technological forces on rural India?

7. What are the pre-industrial values? How city culture affects the rural society?

8. State the characteristics of Industrial Society.

9. What is the impact of industrialization on the contemporary Indian society?

10. Why the process of modernization is very slow in India?

11 Are the policy-makers successful in modernizing India?

12 What are your ideas about modernization of India?

Chapter Sixteen

SCIENCE AND HUMAN VALUES

What is a value? — Nature of value — Science and values — Scientist and values — Man, society and values

Science and technology are the two dominating forces behind modern civilization. In order to understand any civilization we will have to consider a set of cultural values. Values are part and parcel of human life. We must, therefore, inquire into the nature and meaning of value and consider how science and human values are related to each other.

WHAT IS A VALUE?

Since the time of the early Greeks men have used the term value, but until the 19th century it was not recognised as one of the great philosophic topics. Etymologically the Greek word axios means 'worthy', and in this sense the term value is being used for the study of the general theory of value. In the study of the general theory of value, which is called axiology, we consider the origin, the nature, the classification and the place of values in the world. The purpose of this chapter is not to study the entire general theory of value, but to point out the relationship between science and human values. For example, it is asked whether science is good or bad. Is science moral or immoral or amoral? We have to seek answer to such questions. From the above questions, it is clear that the words 'good' or 'bad' have been used as valuational words. As stated in Encyclopaedia of Philosophy, the term value stands for an abstract noun such as desirable, worth, worthwhile, or good. So the above questions are valuational questions which we have to consider. For our purpose, we shall consider the nature of value and the place of values in the scientific and technological world.

THE NATURE OF VALUE

To include all the forms of value we may define **value as a determination or quality of an object which involves any sort of appreciation or interest.** Psychologically, appreciation involves feeling and ultimately desires or tendencies, beneath the feeling. Therefore, value is the feeling. Value and feeling of value are the same thing. For many, this psychological theory explains everything. But for Orestano there is a biological explanation which appears in psychological form, because at the back of desire and feeling, there are certain biological tendencies or instincts. This biological explanation leads to the definition of value in terms of survival and enhancement of life. It is at this point, philosophical theories arise. The biological explanation implies that all the things which satisfy biological tendencies are the means and hence they have **instrument to value.**

If biological values have been related to life, philosophically we can say that the biological explanation assumes that life and its continuance have value. In other words, life has significance from 'absolute' values which it embodies. When we say that life is valuable, we presuppose knowledge of value. As a result of reflection of this type, two main positions are held in the general philosophical theory of value, viz. (i) Values are ultimately indefinable, and (ii) Values have the function of the coherent organization of life as a whole.

Whatever differences there may be, there is substantial agreement that values are not subjective. Those who regard values as subjective, believe that value judgments vary from individual to individual, from group to group, from one age to another. According to subjectivists values depend upon a relationship between an observer and that which is being evaluated. Those who consider objectivity in values believe that values are strictly out there in our world to be discovered. The value fact calls forth our judgment. They must be independent of the observer appealing to man's moral sense or aesthetic faculty. The objectivity to value is central in the philosophies of Plato. Aristotle, in medieval thought and in various types of modern realism and idealism. Various modern realists have formulated positions on the status of values. For E. G. Spaulding, values

are "Subsistents" (i.e. entities not in space and time, but held to be real' rather than "existents" (entities in space and time). The values such as truth, goodness and beauty are independent of human desire and preference, they are in our world to be discovered. The above values are called intrinsic values because they are good in themselves. An intrinsic value is that which is valuable for its own sake and not for its capacity to yield something else. On the contrary, extrinsic value is a means to the attainment of other things. But intrinsic and extrinsic values are not necessarily mutually exclusive. For example, knowledge may be valued as a good in itself and also as means to other things that have value such as economic success or power. The success of human existence depends on the knowledge of the events of nature and the reality.

SCIENCE AND VALUES

Every human society has a set of cultural values, a set of moral preference for certain kinds of social activities. Some of such values are significant for science. One of the key cultural values is the value of rationality. Rationality value means the moral, the emotional, the institutionalized approval of a practice throughout wide areas of the society. The modern world accepts the rule of reason as more important than the rule of custom and ritual. The spirit of free inquiry is another aspect of rationality. The rationality may come into conflict with certain established habits and activities in society such as 'sacred' beliefs of religion.

Science has another cultural value, called utilitarianism. In this context, the word utilitarianism implies that science is interested in the affairs of the natural world rather than transcendental affairs such as supernatural, spirit, soul, etc.

Universalism is another cultural value. It means that for the study of science, there are no bars. It is open for all. But science values individualism because it gives importance to individual conscience rather than to organized authority. Another cultural value is that of progress. It implies that active rationality would improve man's lot in this world. But it must be noted that the system of value is not rigidly constituted even in the societies which realizes it most fully.

The entire modern world is dominated by a materialistic approach to life. This is the consequence of the developments in science and technology. Science and technology are intimately integrated with the whole social structure and cultural tradition. So man is interested in the pursuit of the study of science with all its branches of knowledge. Influence of science upon our thoughts, our hopes and our habits is constantly increasing. Due to man's desire for scientific studies it is imperative to emphasize human values. Without the human values the human intellect may become a formidable and dangerous force.

SCIENTIST AND VALUES

If men desire happiness, the problem is how to derive it. This problem takes a serious turn due to the modern invention of deadly devices. But the scientist may be happy because he may be delighted by experience of discovering new potentials of life. To the scientist knowledge is the end but knowledge can never be obtained without its effect upon himself as a man, without its effect on his emotion, his attitude to life, on his outlook of humanity and his relationship to all. This is a spiritual experience which comes as a result of contact with nature. If science is divorced from human life and values, it would be betrayer of humanity. In short, values are part and parcel of human existence.

MAN, SOCIETY AND VALUES

A civilization is in considerable part a set of ideas, ideals and values. All these act as the cohesive force to hold the various parts of society together. When the values are weakened or lost and when there is no replacement by other equally constructive values, the society tends to break up into conflicting groups. The modern scientific age faces such danger or problem. Both the advanced and backward societies are facing this moral crisis. They also lack the sense of direction. The modern age is in need of a more adequate value system. By an adequate value system we mean recignition of primacy of man and treating man as an end in himself. In an adequate value system there is dedication to peace and sharing of appropriate

values of our civilization with all men in the world. Modern humanism takes the same standpoint. It takes equality as its fundamental value. Equality presupposes that every man is an end in himself and not merely means. Science provides insight into end and means relation. Science itself is a value But science values knowledge for the sake of knowledge. Practical use of science is indirect and human beings treat it as a means for their practical uses and misuses. In fact, scientist believes that science is not actively anti-moral, although indirectly, its effect on morals may be viewed as anti-moral. Its moral is to be in pursuit of disinterested knowledge of truth. But many thinkers prefer to call science as amoral i.e. it is without any morality at all.

Dr. Alexis Carrel in his work 'Man the Unknown' rightly states, "Everybody is interested in things that increase wealth and comfort. But no one understands that the structural, functional and mental quality of each individual has to be improved. The health of intelligence and the affective sense, moral discipline and spiritual development are just as necessary as the health of the body and prevention of infectious diseases". In other words, if men fail to consciously choose scale of values and know what they are for and what they are against they will be adrift in a changing world. It is therefore necessary to create human wisdom with purposiveness and direction to match with human scope and opportunities. We cannot forget the importance of human sense of fellowship and responsibility. Similarly, it is important to infuse human faith in the higher values of life and vision of the immensity of reality to match with human rationality and scientific temper. Lastly, it is necessary to inculcate a spirit of tolerance and accommodation, understanding and assimilation. We shall sum up our discussion in the words of Bertrand Russell, "If increase of knowledge is not matched with increase of wisdom, increase of knowledge will mean increase of ruin."

SUMMARY

In the general theory of value we consider origin, nature classification and the place of values in the world. Our purpose in this chapter is to study the relationship between science and human values. So, we shall consider the meaning and nature of values.

Etymologically, value means something that is desirable, worth, worthwhile or good. These words are often used to ask whether science is good or bad? Is science moral, immoral or amoral? These are the valuational questions and hence the study of the nature of values is important.

Value may be defined as a determination or quality of an object which involves any sort of appreciation or interest. This definition gives rise to mainly two standpoints. (i) Psychological and (ii) Philosophical. The psychological theory is supposed to be a form of biological explanation which in turn gives rise tc philosophical theory. Biological explanation of value in terms of survival and enhancement of life, gives importance to instrumental values or means values. But philosophically, it leads us to think of 'absolute' values because biological explanation assumes that life and its continuance have value. This type of reflection gives rise to two standpoints: (i) values are ultimately indefinable, and (ii) they have the function of the coherent organisation of life as a whole.

Values are not subjective. They are objective, objectivity of value leads to the concept of intrinsic value which means something is valuable for its own sake and not for something else For example, knowledge is valuable for its own sake, but it may also be viewed as having instrumental value or extrinsic value.

Scientists believe that science is amoral But if we regard it as having value in so far as it gives knowledge of truth we may treat it as having cultural values such as rationality, utilitarianism, universalism and individualism.

Influence of science upon our thoughts, hopes and habits is constantly increasing. It is, therefore, imperative to emphasize human values. A scientist treats knowledge as an end but cannot escape from its effect upon himself. So if science is divorced from human life and values, it would be betrayer of humanity. Values are part and parcel of human existence.

By and large, our civilization consists of ideas, ideals and values. If values are destroyed, the society will break up into conflicting groups. It is, therefore, necessary to give a sense cf direction and formulate an adequates value system. We must recognize primacy of man and treat him as an end in himself. Man should dedicate himself to the cause of peace and share the appropriate values with other men. This is the presupposition of equality which is valued most in modern humanism. It is necessary to create human wisdom with purposiveness and direction to match with human scope and opportunity. We must stress fellowship, responsibility, faith in higher values, and vision of reality. We must inculcate a spirit of tolerance, accommodation, understanding and assimilation.

EXERCISES

1. What is value? What is the nature of value?
2. What is the psychological standpoint on value? Is it tenable?
3. Evaluate biological explanation of value.
4. What is the difference between subjectivism and objectivism with regard to values.
5. Distinguish between intrinsic and extrinsic values.
6. How is science related to cultural values?
7. "Values are part and parcel of human existence". Explain.
8. What is the relationship between man, society and values?

Chapter Seventeen

FUTURE OF TECHNOLOGICAL SOCIETY

What is futurology? — Education — Automation and man — Will scarcity be put to an end? — Question of power — Population and food resources — Communications and the exploration of outer space — Nuclear holocaust — Energy needs — Recycle of waste material — Biological warfare — Chemical warfare — Synthesis of life.

WHAT IS FUTUROLOGY?

There is a science known as the science of futurology. In this science the futurologists (scholars and intellectuals) try to discern trends and detect signals warning us of emerging social problems. They also think seriously and critically about alternative solutions to the problems and possible future world, and recommend strategies for achieving those solutions and worlds. Of course, even the most sympathetic and globally-minded scholar can only perceive the world from a particular angle and perspective. His roots in a particular class, nation or race help to determine his choice of problems and the proposed solutions to them. Thus, forecasting is the aim of futurology.

Today the problems of social change and progress and the prospects for the development of science and technology are of concern not only to the solitary thinker but to the hundreds of millions of people all over the world. In technological forecasting one takes a particular science and does guess-work; how it will develop in the next few (five, ten, twenty, twenty-five, hundred) years, what technological innovations will result from it, and therefore, what effect it will have on society over the forseeable future. Much money is currently being spent, in particular in the United States on such activities, both by individual industrial companies and by government. The techniques of technological forecasting were pioneered by Erich

Jantsch, but a particularly striking example of their use is the list of future innovations compiled by Herman Kahn and Anthony Wiener in their book 'The year 2000'—a frame work for speculation on the next thirty-three years.

Forecasting is possile where there are regularities of phenomena or where there are persisting trends whose direction can be plotted with statistical time — series or be formulated as historical tendencies. Therefore, one necessarily deals with possible projections. But the limitations of forecasting are also evident. The further one reaches ahead in time with a set of forecasts, the greater the margin for error, since the span of the projections widens. Of course, it is not that one cannot or should not plan for the future. There is no advantage gained by throwing out the technological-forecasting baby along with his conservative bath water. Rather the normative and social implications of new technologies have to be envisaged. For example, it is not only the straight forward issues of whether unemployment will result from innovation but whether social relationships are themselves modified, and whether this modification is desirable.

McLuhanite dictum that 'anyone who thinks that technology is neutral is a numbskull idiot' should penerate the forecaster's awareness.

The most obvious characteristic of new technology is that it brings about change. By enhancing our ability to measure and predict, technology can more specifically lead to controlled or directed change. Thus, the plow changes the texture of the soil, the wheel speeds up the mobility of people or objects. We can say that any new technological change makes possible a new way of inducing a physical change or creates wholly new physical possibility that simply did not exist before. In so far as the new options are chosen and the new possibilities are exploited, older possibilities are displaced and older options reversed by technology.

Now, knowledge has of course been necessary in the functioning of any society. What is distinctive about the post-industrial society is the change in the character of knowledge itself. What has become decisive for the organization of decisions and the direction of change is the centrality of theoretical

knowledge. Every modern society now lives by innovation and the social control of change, and tries to anticipate the future in order to plan ahead. This commitment to social control introduces the need for planning and forecasting into society. It is the altered nature of innovation that makes theoretical knowledge so crucial.

Philip Eisenberg points out "Many people fear that the swiftly changing world of science, technology and communications may transmit a kind of rootlessness to individual human behaviour. New values, moral and ethical principles pass into and out of our lives at high speed. Individuals may become increasingly incompetent to deal rationally with their environment unable to cope with the accelerated rate of change."

We must say that the affluence is not a universal fact as yet and its effects also have not worked themselves out upto the last consequences. The process is on and it will continue to have its impact on future. We must try to understand it and try to trace its impact on the society.

Technological forecast deals with characteristics, such as level of technological performance (e.g. speed, power, accuracy, etc.). It does not have to state how these characteristics will be achieved. That is, the forecaster need not invent the machine he predicts about. His forecast may even predict characteristics which exceed the limitations of the current means of performing specific functions. The forecaster need not state how these limitations will be surpassed.

The role of technological forecasting is to provide information about future technology; that is, information about the technology which is expected to be available at some future time, or which might be available if the appropriate resources are applied or the technology which will have to be available if certain goals are to be meet.

The role of technological forecasting as a component of the planning and decision-making process, is to convert uncertainty to risk. Though not all of the uncertainty can be converted to risk, often a significant proportion can be. With a forecast, the planner or decision-maker is no longer faced with complete uncertainty. He has some idea of the odds for and against various courses of action. Setting goals for techno-

logy may range from the setting of short range goals for current projects to the setting of long range goals to be achieved through a sequence of projects.

The possible applications of futurology are many—as many as there are problems facing mankind. The major problems facing mankind are automation, education, scarcity, population and food resources, energy, nuclear power, chemical warfare, biological warfare, synthesis of life, space travel, etc. In what follows, we shall see the forecasts in different fields.

EDUCATION

In 1958, the English sociologist Michael Young wrote a fable, the Rise of the Meritocracy. It claims to be a manuscript written in the year 2033. The theme is the transformation of English society, by the turn of the twenty-first century, owing to the victory of the principle of achievement over that of inheritance. For centuries, the key positions in the society had been held by the children of the nobility on the hereditary principle of succession. But in the modern society, the rate of social progress depended on the degree to which power was matched with intelligence. Britain could no longer afford a ruling class without the necessary technical skills. The principle of merit slowly became established, and by 1990 all adults with IQs over 125 belonged to the meritocracy. With the transformation all men of talent were raised into a common status, and those below had no excuses for their failures. They bore the stigma of rejection and were called inferiors.

By the year 2034 the populists had revolted. Though the majority of the rebels were members of the lower classes, the leaders were high-status women, often the wives of leading scientists. The activist women had demanded equality between the sexes, a movement that was then generalized into the demand for equality for all, and for a classless society. The populists won. After little more than half a century, the meritocracy had come to an end. Is this too, the future of the technological society? The technological society is a meritocracy. Different status and differential income depend upon technical skills and higher education. Without those achievements one cannot fulfil the requirements of the new social

division of labour. The post-industrial society differs from society at the turn of the twentieth century. Unlike pre-industrial society, today, in medicine, law, accounting and a dozen of professions one needs a college degree before one can practice one's art. The university, which once reflected the status system of the society has now become the arbiter of class position. As the gatekeeper, it has gained a Quasi-monopoly in determining the future stratification of the society. Any institution which gains a Quasi-monopoly power over the fate of individuals is likely to be subject to quick attack. Thus, it is striking that the populist revolt, which Michael Young foresaw several decades hence has already begun at the very onset of technological society.

Education had traditionally the function of preparing youth to assume full membership in society: (1) by imparting a sense for the history and accumulated knowledge of the race, (2) by imbibing in youth a sense of the culture, mores, practices and values of the group and (3) by teaching a skill or set of skills necessary to a productive social role. This principle is undermined by contemporary and foreseeable technological society. The significant implications for the enterprise of education in technological society are: (1) a decline in the importance of manual skills, (2) development of management skills and (3) instruction in the potentialities and the use of modern intellectual tools. It is no longer sufficient for the student to understand the past, for the here-and-now environment will soon vanish. He must learn to make probabilistic, increasingly long-range assumptions about the future.

The higher education especially will need to attend more deliberately and systematically than it has in recent times to developing the reflective, synthetic, speculative and even contemplative capacities of man. This is because the understanding may be at a relatively greater premium henceforth.

The technology of tomorrow requires not just lettered men ready to work at endlessly repititions jobs, it requires not men who take orders like slaves, aware that the bread depends upon mechanical submission to authority, but men who can make critical judgments, who are quick to spot new relationships in the rapidly changing reality. As C. P. Snow says, "it requires

men who have the future in their bones." Today's fact becomes tomorrow's misinformation. As Heraclitus says, the world is a flux, change. Tomorrow's students, therefore, must learn how to discard old ideas, how and when to replace them. In short, they must learn how to learn. Tomorrow's illiterate will not be man who cannot read, he will be the man who has not learnt how to learn. Tomorrow's curriculum must thus combine factual content with training life-know-how.

Singer writes "each individual carries in his mind not merely a picture of himself at present, a self-image, but a set of pictures of himself as he wishes to be in the future. This person of the future provides a focus for the child. It is a magnet towards he is drawn, the framework for the present one might say, is created by the future." Thus, the student of tomorrow will be asked to speculate freely, not merely about what next week holds in store for them, but about what the next generation holds in store for the entire human race.

Alvin Toffler in his book 'Future Shock' narrates an incidence. Alvin Toffler was giving a lecture on the sociology of the future. The group he was addressing included corporate long-range planners, staff from major foundations, publishers and research centres. Each participant gave his reason for attending. Then came a turn of an old man. He said 'my name is Charles Stein. I am a needle worker all my life. I am seventy-seven years old, and I want to get what I did not get in my youth. I want to know about the future. I want to die an educated man.'

This is going to be the trend of education in future. Student's eyes will be focussed on the future rather than past. When we have a passion about the future we shall have a society far better equipped to meet the impact of change. Thus, Robert Jung, one of Europe's leading futurist — philosophers said "Nowadays almost exclusive stress is laid on learning what has happened and has been done. Tomorrow... at least one-third of all lectures and exercises ought to be concerned with scientific, technical, artistic and philosophical work in progress, anticipated crises and possible future answers to these challenges."

It is not too much to say that if the business firm was the key institution of the past hundred years, because of its role in organizing production, the university will become the central institution of the next hundred years because of its role as the new source of innovation and knowledge.

AUTOMATION AND MAN

Ours is the age of automation or the technocratic age. In this era more and more innovations are added to the existing ones. Of all the modern innovations the one that is certainly to influence most profoundly the society of the future is the computer. This is essentially a calculating machine, but its development and applications are innumerable. R. Beishon rightly observes "so far we have largely begun to tap the possibilities of man-computer co-operation, and it is likely that this alone will lead to some of the most impressive advances in industrial and commercial practice in the near future. At the managerial level the computer will be able to give the manager information about the current state processes. stock levels production rates, etc., and then in response to suggestions from managers it will be able to produce rapidly predictions for the outcome of various control actions which may be contemplated." This machine can work in every sphere of life. Through the use of computer men can guide space satellite, forecast the weather, make the textual analysis of the book, etc. It can still be made to work miracles.

There is no doubt that because of the technological innovations in the era of automation the work will become physically easier. Machines in general and self-regulating machines in particular have even today taken the drudgery out of man's hands. The jobs that were carried through sheer human physical effort, are now handled by mechanical and automatic devices. Excessively high or low temperatures, pressures to which man was usually subjected have become quite remote from the ordinary worker. Thus, the technological development has provided substitutes for human muscle power. Developments in electronic computers are providing mechanical substitutes for at least some of the mental operations. Of course, no technology as yet promises to duplicate human creativity nor are there in the offing mechanical equivalents for the ini-

tiatives inherent in human emotions although emotions can of course be affected by drugs or electrical means. Therefore, one may predict that, for the foreseeable future the human work will be less and less of the muscle and elementary mental kind, and more and more of the intellectual and emotional kind.

The fact that automation results in replacing of man by machine has made some people fear that this trend will cause serious unemployment. In their book, 'The year 2000', Herman Kahn and Anthony J. Wiener, depict a society so affluent (in which per capita income is doubled every eighteen years) that work and efficiency have lost their meaning; and increase in the pace of change will produce future shock. Kahn and Wiener almost assume society in which there is no scarcity and the only problems are how to use abundance. People will become unemployed and feel lonely and useless. This situation may worsen by the use of psychological and chemical devices, especially by manipulating the genes whereby men may become intrinsically submissive and impotent to assess themselves or a new breed of real slaves by nature or by genes may be produced who would do any job required from them or because of automation become unemployed.

It is true that the automation does cause temporary unemployment, but in the long run it will not be the case. As Peter Drucker foresaw many years ago "the essence of automation is the replacement of manual labour, whether skilled or unskilled, by knowledge. It is not 'saving of labour', automation does not mean fewer people at work; often it means more people at work. But it means different people doing different work. It requires such knowledge as is brought to work by the logician, the mathematician, the psychologist, the chemist, the engineer, the economist—a whole host of highly educated people where formerly we employed manual worker."

It is true that today the world is facing the problem of unemployment. But this problem is not due to any effect of automation. It is due to some external conditions like defective planning, and even where in some cases it appears to be due to automation, it is the initial transitional stage in automation and not the automation which is to blame. Man will never

be dispensed with. Even when the control is automatic, feed-back devices will always depend upon the supervision of man, because he is the only being capable of foreseeing and predicting new situations and of taking preventive action. Technology may not displace people by reducing employment, in the aggregate. It displaces some jobs by rendering them more efficiently performed by machines than by people.

In the technological society of the future, there will be the progressive upgrading of work. Since, the drudgery is being passed down to the machine, man will take to other occupations demanding more brain. This is quite obvious from the fact that the white-collar and professional employment is increasing and the manual jobs are fast decreasing.

All technical progress contains unforeseeable, secondary effects. For example, you have a cold in the head; you take an aspirin. The headache disappears, but it is well known today that aspirin has other actions besides doing away with headaches. It has its dangerous effect on the bloodpicture. DDT was thought to be a successful means for the destruction of all kinds of insects. One of the most admirable things about DDT was that it was said to be completely innocuous towards human beings. DDT was sprinkled over the whole surface of the globe. Then by accident, it was discovered that in certain areas cattle were dying. Cattle had been dusted with DDT in order to get rid of insects. They had subsequently licked themselves clean and swallowed the DDT. The chemical passed into their milk. Calves suckled by such cows died of anemia. Research revealed that DDT causes anemia. Automobiles destroy the city and pollute the air. Industries also have their share in air pollution.

The measures to be adopted against air and water pollution and against many other side effects of technology will be another source of useful employment. To combat the side effects of technology, we will need much study, research and experimentation, as well as technology. And this will mean new employment opportunities.

Similarly, the promotion and maintenance of the services that society normally needs will be the sources of occupation. For example, the machine can make tablets, but the doctor must prescribe the formula and the nurse must attend to the patient.

This points to the fact that while the sources of work will not be exhausted in the new society and on account of inventions, work itself will require a higher degree of prestige. The social aspect of work will be considerably enhanced. Men will learn more and more the art of co-operation as they will have to depend upon one another for services. Further, society will be free from economic necessities and there will be ample opportunity for leisure. This will result in the change of outlook. Society will find more use for social labour in modern times than ever before. This will result in the solidarity of community, and healthy human relationship.

WILL SCARCITY BE PUT TO AN END?

In 1930, J. M. Keynes, asked "What can we reasonably expect the level of our economic life to be a hundred years hence? What are the economic possibilities for our grand children?" From the earliest times back to two thousand years before Christ, down to the eighteenth century, "there was no very great change in the standard of life of the average man. But with the combination of technical efficiency and capital accumulation, mankind had discovered the magic of growth building on growth. "If capital increases, say 2 per cent per annum, the capital equipment of the whole world will have increased by a half in twenty years and seven and a half times in hundred years." Think of this in terms of material things—house, transport and the like." And to Keynes this meant, "in the long run that mankind is solving its economic problem. I would predict that the standard of life in progressive countries one hundred years hence will be between four and eight times as high as it is today."

Keynes was so optimistic about the technological development that he said, "if the economic problem is solved, mankind will be deprived of its traditional purpose. Thus, for the first time since his creation man will be faced with the real, his permanent problem—how to use his freedom from pressing economic cares, how to occupy his leisure. which science and compound interest will have won him to live wisely, agreeably and well."

In 1848, in the Communist Manifesto, Marx wrote "The bourgeoisie, during the rule of scarce one hundred years, has created more massive and more colossal productive forces than have all the preceding generations together. Subjection of nature's forces to man, machinery, application of chemistry to industry and agriculture, steam navigation, railway, electric telegraphs, clearing of whole continents for cultivation, canalization of rivers, whole populations conjured out of the ground —what earlier century had even a presentiment that such productive forces slumbered in the leap of social labour."

Engels also writes "Man's own social organization, which in the past confronted him as something imposed by nature and history, now becomes his own free act. The outside, objective forces which until now governed history pass under the control of man himself, only from then on, will man make his own history with complete consciousness. It is the leap of mankind from the Kingdom of necessity into the Kingdom of freedom."

Now the questions arise, has the economic problem been solved? Will scarcity disappear? The answer is no. There were no spectacular jumps in productivity. The detailed study by the American president's commission on technology, automation and economic progress showed that for the past two decades there had been no sharp changes in the rate of productivity and if one looked ahead ten years—the period for which one could identify oncoming technological developments —there were no increases in the offing. In fact the prospects for the economy were quite the reverse. The concept of abolition of scarcity is an emplrical absurdity. Quite paradoxically, the post-industrial society brings with it a whole new set of scarcities for the society. The more income and the greater the abundance in a society, the greater becomes the need for regulation. In their book, 'The Year 2000', Kahn and Wiener predicted that private income in the year 2000 will be $ 10,000 a person as against $ 3,550, in 1965. But will that person be three times as better off just as a person today whose income is twice as high at is was twenty years ago? As incomes rise, there is a greater demand for goods or amenities which are by their nature limited.

QUESTION OF POWER

More than a hundred and fifty years ago, the brilliant technocrat Saint-Simon talked about the emergent society wherein wealth would be created by production and machinery rather than seized through plunder and war. What was needed he said was a breed of "new men"—engineers, builders, planners—who would provide the necessary leadership.

Saint-Simon had a vision of the future society that made him utopian in the eyes of Marx. Society would be a scientific-industrial association whose good would be the highest productive effort to conquer nature and to achieve the greatest possible benefits for all. Men would become happy in their natural abilities. The ideal industrial society would be by no means classless, for individuals were unequal in ability and in capacity. But social divisions would follow actual abilities, as opposed to the artificial divisions of previous societies, and individuals would find happiness and liberty in working at the job to which they were best suited. With every man in his natural place, each would obey his superior spontaneously, as one obeyed one's doctor, for a superior was defined by a higher technical capacity. In industrial society, there would be three major divisions of work. The majority of men were of the motor capacity, within this class, the best would become the production leaders and administrators of society. The second type was the rational one, and men of this capacity would become the scientists, discovering new knowledge and writing the laws that were to guide men. The third type would be the artists and religious leaders.

In the post-industrial society, technical skill becomes the base of power, and education the mode of access to power. Those who come to the fore in this fashion are the scientists. In future, scientist or more widely the technical intelligentia will have to be taken into account in the political process, though they may not have been before. Moreover, science itself is ruled by an ethos which is different from the ethos of other major social groups, and this ethos will predispose scientists to act in a different manner, politically, from other groups.

Future society will be the one dominated by technicians and scientists. Those who hold this view-point maintain that

modern society is based on technology, which in turn is closely allied to science. Management can pursue its goals only by virtue of an advancing technology. Labour is tied to the overwhelming industrial technique. As for the public at large, its way of life and its customary standard of living are entirely dependent on the skills of technical and scientific specialists. Thus, the technicians and scientists are the key men of our civilization. The technicians and scientists in the future society will want to rid themselves of the restrictions imposed by management and labour. There will be a revolution of the technicians. The technicians will succeed because of the strategic power of the technician in the industrial society. Indeed, the technician might come to power. Eventually, the management would become a purely technical job. The manager would be another type of technician. Labour would be regarded as one factor in the process of production. It would be shunted about from one plant to another as needed. Thus, the power will be the monopoly of the technicians and scientists.

POPULATION AND FOOD RESOURCES

In 1900, the world population was roughly about 1,500 million, in 1950 over 2,500 million in 1960 about 3,000 million and today it exceeds 3,500 million. According to UNESCO statistics, given the present rate of increase it will be more than 6,000 million in the year 2000. Naturally, the production of food will have to be tribled by 2000 to provide enough food to this population Today the scientists and technologists are thinking about the possibilities for increasing food resources. According to Fritz Baade, it would be quite possible to double or even trible the area of land under cultivation. It would also be possible to increase yields on the existing area by application of agro-technical advances. Today animals are used in cultivation. But in future times the mechanied cultivation alone would, in his opinion, lead to an increase in yield which would provide food for another thousand million people at least. The forecasts of the experts from the U.S. Department of Agriculture also strengthen the argument of Fritz. These experts argue, if the present rate of agricultural output is maintained, there will be twice as much food in the economically developed countries by the year 2000 than is required

for meeting the needs of the comparatively slowly rising population of these countries.

Closely bound up with this is the problem of rationalizing the size of the world population in the future. George Thomson and many other scientists believe that cultural and economic development and increasingly wide spread use of contraceptives will considerably reduce the growth rate if world population.

Living-space for rapidly growing mankind is a problem, but it can be solved. The American scientist John Fisher thinks that colonisation of planets and asteroids, will begin in the first half of the 21st century and that an additional century may lead to the colonization of perhaps a thousand asteroids, and in few more centuries these city-states will each have a population comparable to one of today's nations. Forecasting the more immediate future John Bernal and Prof. Ardenne say, by 2000, irrigation of vast expances will be possible, as well as the comprehensive mechanization of agriculture and the synthetic production of food. All this in their opinion, "will produce such a sharp increase in the production of food that even with a substantial rise in the world population no one will starve."

The world's food supply is inadequate in quantity and quality. Malnutrition and starvation are common in many countries. Prompt action is needed to meet this condition. The entire organization of government and the societies are involved The introduction of new crop varieties, improvement of animal breeds, application of pest and disease control and the prevention of after-harvest loss will solve the food problem to the considerable extent. In the future it is most likely that we are going to have many new products. By increasing the use of modern food technology throughout the world, it is possible to make tremendous advance in the use of food. Parts of many food crops are wasted because even simplest technological knowledge is not available to prolong the crop season, to preserve perishable food and to prevent loss from insects and other pests. Further, recycling of food will go a long way in meeting the food demand.

Food from sea: Fish will be a major source of food for man in the future. At least 40 million tons of fish are eaten by man

every year. Harvesting a fish is essentially a hunting economy. Ocean fisheries are mostly common property. Control over these fisheries can be exerted only by international agreements. Greater use of the fishery resources of the world is now being pressed by several countries.

Some fishery scientists hold that the present yield of about 40 million tons a year can be increased tenfold. Some forecasters also hold that a hundred fold increase is quite conceivable. Most fish have a far greater reproduction potential than land animals. Females of many species produce millions of eggs. In the future, the adequate protection to these eggs will be offered so that the vast increase in the yield could be obtained. Moreover, artificial rearing of fish is possible.

It is true that the ocean has a tremendous number of fish in it, but there are large areas of the ocean that are just as barren as desert land. We do not know too much about fishing, but what we do know is very important. There are fertile areas in the ocean, where we can have promising yields. In the future, these unexplored areas will be explored.

Fishery products are excellent sources of good quality protein, valuable minerals and essential B complex vitamins. Therefore fish is a particularly desirable food for modern human diet.

One of the serious limitations of using fish in the past was the need for refrigeration, quick canning or freezing—all of these processes are expensive. This problem is being tackled. Moreover, the present efforts are directed largely toward making a suitable fish flour or protein concentrate. There are many technological problems in this process; but a good products can be made from the whole fish. It is bacteriologically safe, there are no toxins in it, it is tasteless, odorless, and it can be eaten in bread and in soup. Thus increased reliance on the food from sea will alter the nutrition of millions and also solve the food problem.

Nesmeyanov, a Russian futurologist forecasts that in the future, the economics of food synthesis may prevail over food obtained in the traditional way. If this is the case, a few factories running on coal or oil will be capable of producing food to meet the requirements of the whole population, and

labour-consuming agriculture will become a thing of the past. The old food industry will be replaced by a new. Mankind will no longer suffer the tremendous food losses caused by bad weather, natural disasters, pests, decay and other evils which spoil a considerable part of the harvest at the present time. Occupations linked with the domestic preparation of food will die out and housewives will be released from their burdensome task.

COMMUNICATIONS AND THE EXPLORATION OF OUTER SPACE

In future society, the large stereoscopic and stereophonic TV colour screens will allow people to meet one another at a distance or visit various places, experiencing fully the sensation of being there. This will reduce the need for travelling considerably. Similarly, the development of radio-video-telephonic and photo-telegraphic communications will help the people to pass on necessary information quickly. John Cokroft believes that in the next few decades, the widespread use of lasers, whose modulated beam is capable of carrying a large volume of information, would lead to important advances in the sphere of communication.

Practically every writer, writing on the future of mankind, pays attention to the problem of the exploration of outer space. These thinkers connect the solution of many pressing problems of our time, such as world population, mineral resources, information and even the structure of future society with the prospects of conquering outer space. There in no doubt that the development of space exploration will have an important influence on the development of science and whole of social production.

A. C. Clarke predicts that in the next century, mankind will be able to use nuclear energy for space flights, so that travelling to the most remote planet in the solar system will not take more than a week. When the speed of spaceship is near to that of light, it will take only five hours to travel from Earth to the nearest star. He even examines the hypotheses which seem like pure fantasy at the present time: a change in the structure of space under the influence of gravitational fields,

an increase in the speed of transportation up to the speed of light and even the possibility of reaching any point in outer space immediately.

The future for the conquest of outer space is linked with two problems. The possibility of astronauts visiting civilizations on other planets and the possibility of establishing interstellar radio communications. A. C. Clarke believes that contact with extraterrestrial civilizations will be established before 2030. The search for intelligent life in the universe is recognised as important for the future conquest of outer space. This problem, which for a long time was simply an object of abstract discussion has turned up on the agenda of science. K. Tsiol-Kovsky examined the possibility of setting up industry in the ether, and it is no accident that today one of the most important lines of basic and applied research is advancing towards setting up industry in outer space. For example, Soviet scientists have produced technical projects for solar and atomic electric power stations in outer space, oxygen producing devices on the Moon, etc.

As Fred Hoyle says "one day Earth people will make their contribution to galatic culture and be invited to the round table of the interstellar club where galactic problems are discussed."

NUCLEAR HOLOCAUST

The atom bomb, and still more the hydrogen bomb, have caused new fears, involving new doubts as to the effects of science on human life. Some eminent scientists, including Einstein, have pointed out that there is a danger of extinction of all life on our planet due to nuclear power. Let us see how risks are associated with nuclear power.

Firstly, risks are associated with nuclear power plant. The risks from nuclear power plant are due to the radioactivity formed by the fission process. Radioactive materials escape into the environment at every stage of the production of nuclear power, from the mining and milling of uranium to the decommissioning of an old power plant. In normal operations, nuclear power plants release minute amounts of this radioactivity under controlled conditions. In the event of a highly unlikely accident, larger amounts of radioactivity could

be released and could cause significant injuries or fatalities. The fragments of the uranium atom that remain after fission are radioactive. These radioactive atoms are called fission products. They disintegrate further with the release of nuclear radiation. Many of them decay away quickly, in a matter of minutes, or hours, to non-radioactive forms, others decay away more slowly and require months and in a few cases, many years to decay.

The hazards of plutonium arise not only from its explosive properties, but from its extreme radioactivity. Dispersed into the atmosphere by conventional explosives a small quantity of plutonium could cause an indeterminate number of deaths from lung cancer. Plutonium has sometimes been compared in toxicity with some of the very powerful biological toxins, like botulinus. The latter are somewhat more deadly. They kill the victims rapdily, in a day or two. Plutnonium-239, on the other hand, remains a hazard for nearly half a million years—more than one Ice Age may come and go before its dangers disappear. Unlike the bacterial toxins, plutonium acts slowly. Small doses in the lungs may not produce cancer for 10, 20 or 30 years. Gofman believes that this inhaled plutonium has already induced about 1,00,000 cases of lung cancer in the United States alone, and that perhaps 10,000 persons per year in the whole Northern Hemisphere may be dying from this cause. Since cancers due to plutonium cannot be distinguished from other cancers, there is no way of verifying this by direct observation of the patients. The consequence of introduction of plutonium into the environment, on the very large scale required by an intensive nuclear power programme, may be even more dangerous than we can now perceive.

Exposure to radiation affects all living beings in similar ways. Energetic rays and particles emitted from the radioactive material disrupt chemical bonds in living matter. If the dose is strong, it kills cells or entire organism outright. Sometimes the doses cause changes in the informational material of the cell. If the affected cell is a sex cell, a mutant offspring will be produced which, if it survives can transmit faulty information to its offspring, and so on indefinitely. Prenatal exposure sometimes cause developmental abnormalities.

Secondly, the development of nuclear power and the increased use of radioactive isotopes for research and other purposes both in hospitals and industry, has engendered a need for the disposal of radioactive waste waters. Wastes of high radioactive level usually involves large amounts of activity in a small volume of waste material and can be stored in such a way that no leakage to the environment can occur. In several instances, wastes of low activity are disposed of by discharge to sea through long pipe lines, but in others disposal is to rivers. This has created the problems of water pollution. If fish is thus exposed to radioactivity, the fish eaters will have all the adverse effects of radioactivity.

Thirdly, the major consequence of nuclear power is that the nations will have an access to the material and technology for nuclear weapons. In 1974, India exploded a 'peaceful nuclear device'. and with it she asserted that there is a practical distinction between peaceful and military uses of nuclear energy. Other major nations also maintain the same thing. But the reality is that almost any nation with civilian nuclear power can build a bomb if it so chooses. And if these bombs are used in military operations, the history of the world will come to an end. The atomic weapons are the most destructive weapons. The nation may mean to hit the military target, but with radioactivity even the neighbouring areas suffer. If nations use nuclear weapons, slowly and gradually, the earth will become unfit for supporting life. The atom bomb exploded the air over Hiroshima and Nagasaki. The immediate result was horrible. It took away many lives. But the subsequent radiation deaths and genetic damage produced a toll that is still being counted. So far as nuclear weapons are concerned, they are much more powerful than any other type of weapons in the destruction of material objects as well as human, animal and plant lives. If the war objective is the destruction of property as well as human, animal and plant lives, nations will use nuclear weapons.

Fourthly, the use of nuclear power inevitably brings a real danger of nuclear blackmail and sabotage from terrorists, extremists and criminals. If a world-wide plutonium industry develops—theft of plutonium or even growth of an international blackmarket in plutonium—seems likely.

Alvin Weinberg, bomb project physicist and former White House energy advisor, is in favour of nuclear power. Admitting some disadvantages of nuclear power to be weighed against the disadvantages, he calls the choice "Fautian bargain" for society and urges for nuclear power. But we must remember that the momentum that now drives the expansion of nuclear power has removed the decision from the hands, of the scientists, however: if and when the disputes are settled, the choice of society's energy source will be sought out by the politicians.

Human reason can influence but cannot determine the role and control of nuclear weapons in the future. The tricky course of technology and the occasional intrusion of irrationality will also have their say. National leaders and the experts who serve them might find both expedient and proper to resolve nuclear policy questions (weapon development, arm control, etc.) essentially on the basis of the parochial needs of their individual societies. The aim of each nation would be to maximise its might and its options while minimizing risks to the fullest possible extent.

ENERGY NEEDS

Energy consumption and the world population have grown steadily over the last hundred years. The energy consumption per capita has increased. The world has become dependent upon energy as an important factor in the standard of living and industrial growth. Industrialized nations have become heavily dependent upon the uses of energy resources. The economic growth of nations has been linked with the increased consumption of energy. The evolution of the social and cultural development of a nation is related to that nation's wise use of energy and technology. The cultural development of a nation may be related to the amount of energy per capita consumed, and the efficiency, of the technological means with which it is put to work. The cultural and social well-being of nation may increase as its technological use of energy incresaes effectively. During the past two decades there has been an increasing tendency for industry and transportation to become more energy-intensive. Most industries responded to increased demand for production by becoming more energy intensive and

less labor-intensive. And therefore, one is deeply concerned about the energy for the future.

Petroleum has assumed an important role as an energy source in the world. The world economy is heavily dependent upon oil. Nevertheless, oil like natural gas and coal, is limited in supply. The supply of oil might stop as and when the reservoirs of oil are exhausted. The increased use of oil around the world is causing an accute problem of supply and demand. This has resulted in price increase everywhere.

The electric energy consumption of the world is continuing to grow. The expanded utilization of electricity as an energy carrier will depend upon the increased availability of hydroelectric, nuclear and coal-fired plants. Since electric energy is becoming an increasingly important means of transport energy, electric autos, electric cars, trains may become an important part of our transportation system.

Nuclear power plants may supply the major portion of energy. Of course, because of the radioactivity of the plants, many people are sceptical about these plants. Their fear may limit the development of the nuclear-plants. But the growing demand for energy might overcome this resistance, and many nuclear-power plants will be set up for the supply of energy. As Glenn T. Seaborg says 'by the 1990's we will be well over the difficulties and resistence facing nuclear power today and that more than a third of our electric power will be generated by nuclear plants. Nuclear fusion power and energy from the oceans and winds may contribute significantly to energy resources by the end of this century. Nuclear fusion is still in research and development stage; it will require an engineering breakthrough to bring fusion power to commercial use by the year 2000. Wind power will be another source of energy. Many small wind machines will be set up to contribute to the need of energy. The unequal heating of the Earth's surface produces air masses of differing heat content and density and creates a simple atmospheric heat machine that drives the winds. The winds, as we know, are invariable in place. time and intensity. In order to generate electric power from winds the wind mills are set up. As other sources of energy become relatively scarce

and more expensive, the world will return to this ancient power source.

Solar energy methods will be a significant contributor to energy needs. Solar energy—the energy received by the Earth from the sun has provided, directly or indirectly, almost all the sources of energy for the Earth since its creation. All animal and plant life upon the Earth. has always depended for existence upon the sun's energy. Most importantly, the sun's rays provide the heat necessary to maintain the temperature required for human, animal and plant survival. Sunshine consists of a wide variety of electro-magnetic waves that are similar in many ways to radio and TV waves. Its three main components are invisible heat waves, visible light rays of various colours, and invisible ultraviolet rays. Apart from the more obvious uses of the sun's direct heat, such as drying food and warming people, the most common method of using solar energy directly has been in a green house. Green house is a glass structure that provides a controlled climate for growing plants. This is a surprisingly effective method of converting and trapping the sun's radiation in the form of heat. In the similar fashion the sun's energy for household and water heating can be captured. The principle contribution of solar energy by the year 2000 will be in the heating of new residential and commercial buildings. The result will be a slight reduction in electricity load demand for such purposes. Slowly and gradually, with new technology. the solar energy will be converted into electricity. This energy could be used for industrial purpose. By the year 2000, solar energy will become an important part of our energy supply.

As the energy supply is becoming scarce and the price of oil continues to increase, the economy will force the nations to utilize the energy of waste materials. Recycling of materials will gradually become a significant contributor to the energy. The recycling of used metals reduces the need for additional raw materials and energy use.

If the nations do not discover new sources of energy, with rapid growth of population, and increasing demand for energy, the nations will face the problem of unemployment. Energy is the very heart of industry. Therefore, the nations may think of co-operative research in the hunt for new sources of energy.

RECYCLE OF WASTE MATERIAL

Recycle society is one in which all materials used are reused indefinitely. With increasing population, growing economic needs and limited resources and energy crisis, we are definitely moving toward a 'recycle society'.

All human and industrial processes produce waste. This waste consists of normally unused and undesirable products of a specific process. The waste products of a home include paper, containers, tin cans, aluminium cans, food scraps as well as sewage. The waste products of industry include paper, wood and metal scraps, as well as agricultural waste products.

In a recycle society of tomorrow, all waste and scrap will become our major resources, and our natural, untapped resources will become our backup supplies. The recycling of used metals reduces the need for additional raw materials and energy use. The recycling of metals, such as scrap aluminium or steel will help in conserving energy. We know that more energy is consumed in the original manufacture of these metals than is consumed in the recycling process. Moreover recycled steel can be used in combination with new steel. Similarly, it will be of advantage to recycle aluminium than to produce new aluminium from bauxite ore.

Many materials from municipal sewage as wood, ferrous metal, aluminium, copper, glass, tar, textile, oil, paper and plastics also will be recycled. Recycled newspaper, can be used to make cardboard for containers. Plastics could be recycled and would achieve as much as seventy-five per cent energy savings. If we recycled every automobile, we could save about 30 per cent of the energy required for production of a new car using new materials. Recycling of steel, aluminium and other materials would not only save energy, but also save raw materials.

The recycle-society involves the following implications.

In the recycle society the products will be built to be more durable. They will be easily repairable with standardized, replaceable parts. They will be repaired with very basic tools. All products and parts will be labelled in such a way that their use, origin and material content can be readily identified. Many

items of furniture, housewares, appliances and tools will be multi-functional. They will be designed for easy assembly. Their design and construction will be such that they can be reassembled and redesigned into essentially new products when the consumer seeks a change.

When a consumer wishes to replace an item for something better or different, he can return the old item for standard price. All stores will thus become collection centres as well as selling outlets in the recycle society. After receiving used products, the manufacturers will recondition them. They can use their parts as replacement parts in new products or scrap them for recycled materials.

Further the methods of disposing of municipal sewage are very old. These methods are to a great extent responsible for the pollution of river, streams, lakes and even seas. The recycle society will find these methods obsolete. In the recycle society, the municipal sewage will be recycled and used for generating energy.

Lastly, agricultural wastes, both manure and crop residues have become a major source of environmental pollution. For example, a cow generates as much manure as sixteen humans. A similar problem exists with piles of crop residues. Some of these wastes are finding their way into streams, ponds and other vital water resources. These wastes produce unpleasant odours and pollute the air and water. They also become a breeding place for insects. These wastes, would, therefore, be recycled in the recycle society. Currently, animal wastes are surface-buried to speed the return of the nutrients to the soil and to avoid unpleasant odors and insect breeding. By processing, crop residues and extracting proteins, fats and vitamins, we have been able to make some use of them. Some of the dried residues have been used whole for animal bedding, materials and some like nut shells have been used as dust carriers for various chemicals. Residues have been dried on ground and used as live stock food supplements. By-products today make up more than one-third of the poultry rations. They are also important in feeding beef and dairy cattle.

Thus, the recycle society will be using all resources with maximum efficiency and effectiveness and a minimum of environmental impact.

BIOLOGICAL WARFARE

Biological warfare is a kind of warfare in which disease-producing germs and their products are used against man, animals, food crops and plants by the enemy. There is no authentic information about the use of biological weapons. But there are allegations against Japan and United States of America of having used biological weapons for military purposes. Japanese used biological weapons against China in World War II and Americans used them against Korea in Korean War. Japanese are said to have entered into biological warfare by spreading bacteria from aircraft, dropping special bacterial bombs from aircraft and infecting water-sources and inhabited areas of the land. The microbic agents most prominently used were those of plague, cholera, typhoid, and anthrax. The Americans also are said to have used bacteria which caused an outbreak of plague. Attempts were made to infect water resources with cholera germs from the air.

Microbiology is indebted to the works of Pasteur, Robert Koch and many others. They have made possible the knowledge of micro-organisms. By the close of nineteenth century a great variety of micro-organisms have been identified as occurring in definite association with human or animal disease. Later on the identification of other types of disease producing micro-organisms such as viruses was made possible. Viruses were discovered in 1892 by the Russian botanist Ivanovsky. There are more than fifty different diseases of man which are believed to be induced by viruses. A number of infectious diseases are used as agents in biological warfare. Some of them are: anthrax, cholera, dysentery, influenza, plague, pneumonia, tuberculosis, typhoid fever, yellow fever, small pox, cow pox, sheep pox, etc.

It is not a problem to get a sufficient quantity of biological warfare agents. Under appropriate conditions of cultivation, bacteria grow remarkably. It is also possible to keep a culture growing for an indefinite period of time. In future the cheaper

resources which might be used in the growing of bacteria may be slaughter house wastes, food industries wastes, milk industry by-product and sugar, etc.

After production these infective agents are transferred to suitable containers forming part of the weapon. Delicate organisms are preserved alive and virulent for a considerable length of time by freezing and drying. Many other agents like those of influenza virus are kept alive for long periods by drying them rapidly from the frozen state and then storing them in sealed containers in a cool place. In many cases ordinary refrigeration or rapid drying alone is sufficient. Types of containers for infective agents and the manner of packing them depend upon the nature and physical state of the agent and upon the use to which it is put. Suppose, the agents are airborne agent. In that case the containers will have to be specially designed. Containers from infected vectors (fleas, flies, rats, mosquitoes, certain birds, etc.) must be constructed in such a way that they permit survival of the vectors inside for the required periods and allow safe landing from aircraft. Moreover, the containers must be such as to insure liberation of the vectors on the ground. Aircrafts are the most useful means of dissemination of all biological warfare agents. Rockets also may be used as the means dissemination of biological warfare agents. Because of the minute dimensions of microorganisms, they can be easily dispersed in the form of clouds of great dimensions which can move for very long distances. In future the technology may advance whereby the dissemination of biological warfare agents via infected aircraft bombs, artillery shells or even small bombs of the hand-granade type is possible.

Advantages of Biological Warfare: Firstly, some of the biological warfare agents enter the human body most effectively through nose. These can be either bacteria like plague, viruses like influenza or even fungi. Some agents enter the body through eye, others are most effectively absorbed orally with food or infected water. Naturally, this makes the diagnostic approach extremely difficult. Since it is difficult to identity bacteria, it is difficult to control biological agents.

Secondly, these biological warfare agents are alive and can reproduce. All infections are transmissible if the agents of infections can find their way from person to person. Thus there is a chain of infection. This results in epidemic.

Thirdly, biological warfare agents do not require large expensive equipment for their use, especially in comparison with nuclear weapons. They can be produced in any well equipped laboratory on a large scale to meet the military requirements.

Fourthly, when the biological warfare is against crops and plants, the crops and plants will be destroyed. This will make the enemy starve. Similarly when the warfare is directed against animals, there will be shortage not only of meat but also milk, milk products, eggs, leather, wool and other products. This will be hazardous to an enemy.

Fifthly, biological weapons are directed towards human beings, animals and plants. They do not cause any damage to property. Because of these advantages there is a possibility that biological warfare agents may be used in future for specific military operations. The agents like those of influenza and plague may be used for reduction of the strongholds of the enemy. They can be used for killing useful animals and crops. Who knows, they will also be used for attack on static civic population centres. This will have its impact on the morale of the people and there will be a panicky situation. Biological warfare agents will be most effective in an underdeveloped country where there is a low level of sanitary and public health facilities. The constructive understanding of life which biology has provided may be used for wholesale destruction of life. Once undertaken, war, in the future as in the past, is liable to grow beyond control, whether it be conducted with physical, chemical or biological means. A future for man can be assured only when the danger of modern war is fully recognized or mankind abandons warfare.

CHEMICAL WARFARE

Most of the weapons used in war today are chemical weapons. These weapons have brought miseries to mankind. Chemical weapons like choking gases, vomiting gases, blood

gases, vesicants, nerve gases, incapacitating gas are used in warfare.

Choking Gases: Choking gases cause irritations of the breathing system. They are so powerful that they not only cause irritations, they are capable of destroying the delicate membrances of the lungs. This leads to the blockage of oxygen uptake and result is the death of victim.

Vomiting Gases: These gases are termed as riot controlling gases. Some of them are irritating to the eyes, some to the innèr surface of the nose and upper breathing tubes and some to the skin. Body reacts to these irritations by vomiting. Therefore, they are termed as vomiting gases. When a victim is exposed to these gases, there is also a desire to scratch.

Blood Gases: These gases are rapidly absorbed into the blood circulation. They rapidly block oxygen circulation around the body. The result is the immediate death of the victim. Since these gases act very quickly, it is very difficult to build defences against them.

Vesicants: There are two types of vesicants. They are arsenical and mustards. Arsenicals have irritating odors and cause immediate eye pain. Mustards are odorless and do not cause initial plain. They work slowly but their effect is most damaging. After three hours the victim may become blind and may be rendered incapable of any action. Vesicants in general injure every part of the body with which they come into conduct.

Nerve Gases: The important nerve gases are tabun and sarin. Nerve gases adversely affect the nervous system of the victim. The victim loses his control on the affected part of the nervous system. When a victim is exposed to nerve gases, breathing is difficult, there is coughing, nausea, heartburn, vomiting, urination. If the dose is high there will be collapse, paralysis and death. Sarin is shown to be superior to Tabun for military purposes. It is about fourteen times more toxic than mustard gas. Even a few breaths of hydrocyanic acid are sufficient to cause death within a few minutes.

Incapacitating Agents: These agents are very popular among chemical warfare theorists. Incapacitating agents are

also termed as psychochemical drugs. These agents make an individual practically incapable of carrying out normal duties for a number of hours. Their purpose is not to kill the enemy, but simply to put him out of action for several hours.

Dissemination of Gases

Chemicals are mostly used in the form of aerosols (clouds) They are not dispersed as droplets. Solid particles are dispersed, which directly turn into gas. Chemical warfare does not require complicated delivery system. Granade-throwers, artillery, aircraft, missiles etc. could be used for this purpose. Another way of dissemination which is adopted by Americans in Vietnam is the dispersion of the powder by means of a high velocity wind machine. This machine is nicknamed "Mighty Mite' by Americans.

An attack by a single bomber, dispersing one of the more deadly nerve gases could kill most unprotected persons within an area of at least five square miles. From this one can imagine the destructive power of chemical warfare. Morevover, tear-gas can be used for reducing the accuracy of enemy rifle fire. This will allow one's own forces to approach more closely. Tear-gas can be used to force men out of protection cover and into the line of fires or the path of bomb. In World War I, 12,000 tons of mustard gas caused 400,000 casualties. Napalm is a chemical weapon. This weapon has played havoc in Vietnam. It has taken the lives of innumerable people in Vietnam. Chemicals were used against forested and agricultural lands. These chemicals have been used to damage or kill plants. These chemicals help clear jungle for military purposes and also to deprive the enemy for food resources. Depriving farmer communities permanently of their food resources constitutes a crime against humanity.

Thus, if the chemical warfare breaks in future, it will result in the destruction of human, animal and plant lives. This globe will not be fit for the survival of life.

International law prohibits chemical warfare. The General Protocol was signed on 17th June, 1925. This protocol provides for the prohibition of chemical and biological weapons. This protocol has been ratified by all major powers except Japan

and the United States. This creates various doubts about the future chemical warfare. It is important for nations to understand that it is in their long term interest to prevent the use of chemical weapons.

The proponents of chemical warfare visualize the possibility of winning wars, by temporarily, incapacitating the people who do the fighting. There would be no fractured bodies and minds. The factories, homes and property will be unaffected. The victor in the war would not have to feed and cloth vanquished as the defeated nation's economy would not be destroyed. This kind of war with chemical weapons appears to be quite feasible. A future for man can be assured only when the ultimate danger of modern war is fully recognised and mankind abaondons war.

SYNTHESIS OF LIFE

Man's understanding of the biological science has developed to such an extent that now, man will be able to redesign not only individual bodies, but the entire human race. Dr. Watson and Crick received the Nobel Prize in 1962 for describing the DNA molecule. Since then new investigations in genetics have been made. These investigations have offered the possibility of synthetic production of life.

In the years to come it will be possible for a man to make biological carbon copies of himself. 'Cloning' is going to shake the human race. 'Cloning' is the process of growing from the nucleus of an adult cell, a new organism that has the same genetic characteristics of the person contributing the cell nucleus. Cloning would make it possible for people to see themselves born a new. But Cloning will also be creating problems. If people like Newton, Galileo, Einstein, Gandhi, Martin Leuther King, Shakesphere, Kalidas use Cloning, and see themselves born again, the world will be benefited. But what if people like Hitler, Mussolini, Changezkhan use 'Cloning'?

Ledergberg says 'Cloning' may become a reality in ten years time. Scientists will learn how the various organs of the body develop, and they will begin to experiment with various means of modifying them.

Dr. Hafez says, within ten years time a woman will be able to buy a tiny frozen embryo in the store, take it to her doctor, have it implanted in her uterus, carry it for nine months and then give birth to it as though it has been conceived in her own body.

Further, it will be possible to do away with female uterus altogether. Present evidence shows that reproduction can take place outside the human body. Only last year, ovum was fertised outside the mother's womb, and the baby was born. So in future we can do away with female uterus. The impact of new birth technology on family is going to be immense. When babies can be grown in a laboratory jar, what will happen to the notion of maternity? Women are proud of their ability to bear children. In the eyes of the society also they enjoy a status because of their ability to bear children. What will happen to her status, if the child literally not be hers, but that of genetically superior ovum, implanted in her from another woman, or even grown in a laboratory jar?

Just as the concept of motherhood, will be undergoing change, the concept of parenthood also will be revised. It will bs possible for a child to have more than two biological parents. The research in this direction is quite successful. Dr. Beatrice Mintz has grown 'multi-mice' — baby mice each of which has more than the usual number of parents. His method is simple. He took embryos from each of two pregnant mice. He placed these embryos in a laboratory dish and nurtured until they formed a single growing mass. This growing mass is afterward implanted in the womb of a third female mouse. When the baby was born, it showed the genetic characteristics of both sets of parents. Thus a multi-mouse is born. The birth of a multi-mouse points to the fact that the birth of a multi-man is possible in future.

SUMMARY

Futurology forecasts the future events. Technology brings about change. With its present pace it is going to bring about radical social changes. As such what will be the future of technological society is a question that concerns everyone of us. Social scientists and thinkers work in this direction, and forecast the future of technological society. The techniques of technological forecasting were pioneered by Erich

Jantsch. Since then we have a galaxy of forecasters. The knowledge of future events is necessary, for then only the society can deal effectively with the future. Every modern society now lives by innovations and the social control of change, and tries to anticipate the future in order to plan ahead.

Education traditionally had the function of preparing youth to assume full membership in society: (1) by imparting a sense for the history and accumulated knowledge of race, (2) by imbibing in youth a sense of the culture, mores, practices and values of the group, and (3) by teaching a skill or set of skills necessary to a productive social role.

This principle is undermined by a contemporary and foreseeable technological society. The significant implications for the enterprise of education in technological society are: (1) a decline in the importance of manual skills, (2) development of management skills, and (3) instruction in the potentialities and the use of modern intellectual tools. It is not sufficient for the student to understand the past. He must learn to anticipate the direction and rate of chage. The technology of tomorrow requires not just lettered men or men who take orders like slaves, but men who can make critical judgements. As C. P. Snow, says, 'it requires men who have the future in their bones.'

In an industrial society, more and more machines are added to the existing ones. Machines in general and self-regulating machines in particular have taken the drudgery out of man's hands. The jobs that were carried through sheer human physical effort, are now handled by mechanical and automatic devices. The technological development has provided substitutes for human muscle power. Some thinkers argue that the machine will replace man in most of the spheres, and render him unemployed. But as Peter Drucker foresaw, the automation may not result in unemployment. Man will never be dispensed with. Even when the control is automatic, feed back devices will always depend upon the supervision of man. Since the drudgery is passed down to the machine, man will take to other occupations, demanding more brain. Further, all technical progress contains unforseeable secondary effects. Anemia in case of DDT and air pollution in case of automobiles and factories may be cited. To combat such side effects of technology, the society will need much study, research as well as technology. And this will mean new employment opportunities. The promotion and maintenance of services also will be the sources of occupation. Thus automation will not necessarily result in unemployment.

Will the scarcity be put to an end in post-industrial society? No. The concept of abolition of scarcity is an empirical absurdity. Quite paradoxically, the post-industrial society will bring with it a whole new set of scarcities for society. In the affluent society, the incomes rise. As incomes rise, there is a greater demand for goods, amenities which are by their nature limited. Society in the future will not be a class-less society. There will be classes, but the division of society

will be based upon actual abilities (merits) as opposed to the artificial division of the previous society. The technological skill will become the base of power and education the mode of access to power.

According to UNESCO statistics, given the present rate of increase in population, it will be more than 6,000 million in the year 2000. This fact upsets many thinkers. They present a gloomy picture of the future society. But there are thinkers like Fritz Baad, John Fisher, Nesmeyanoy and many others who are optimistic about future. Fritz says that even if population increases, it would be possible to double or even trible the area of land under cultivation. Moreover, it would be possible to increase yields on the existing area by application of agro-technical devices. According to John Fisher, the problem of living-space will be solved in future by colonization of planets and asteroids. Nesmeyanoy thinks that the problem of food will be solved by the economics of food synthesis.

With the technological innovations, man in future will be able to solve the problem of communication more efficiently. As Cockroft believes, the widespread use of lasers would lead to important advances in the sphere of communication. The future for the conquest of outer space is linked with the problems of communication. The future for the conquest of outer space is linked with two problems: the possibility of astronauts visiting civilizations on other planets and the possibility of interstellar radio communicaton. A. C. Clarke believes that contact with extra-terrestrial civilizations will be established before 2030. And finally as Fred Hoyle says 'One day Earth peope will make their contribution to galactic cultures and be invited to the round table of the inter-stellar club where galactic problems are discussed.

Nuclear power in the form of atom bomb has caused new fears. Nuclear power has caused havoc in Hiroshima and Nagasaki. The atomic weapons are the most destructive weapons. They destroy human, animal, and plant lives as well as property. Moreover, risks are associated with nuclear power plant. Radiactive materials escape into the environment at every stage of production of nuclear power. From the mining and milling of uranium to the decommissioning of an old power plant, there is a risk of leakage of radioactive materials into the environment. Plutonium and uranium are used as fuel in nuclear power plant. If plutonium is discharged into the environment, it can cause an indeterminate number of deaths from lung cancer. Gofman believes that inhaled plutonium has already induced about 100,000 cases of lung cancer in the United States alone. Exposure to radiation disrupts chemical bonds in living matter. If the dose is strong, it kills the cells or entire organism. Apart from these hazards, the nations will have an access to the material and technology for nuclear weapons. If nuclear weapons are used in future, the history of the world will come to an end. And even if the nuclear weapons are not used, it is quite feasible that there will be a nuclear blackmail and sabotage from terrorists, extremists and criminals.

Energy consumption and the world population have grown steadily over the last hundred years. Industrialized nations have become heavily dependent upon energy. There has been an increasing tendency for ihdustry and transportation to become more energy intensive. The energy consumption per capita also has increased. This situation makes the thinkers worry about energy. The supply of petroleum and coal is limited and the reservoirs may be exhausted. So the world will have to depend upon other sources of energy. Nuclear energy will be a significant countributor in this direction. The need for energy will force the nations set up nuclear plants. Even if there is a resistence to nuclear power because of its hazards, the resistence will be overcome. Wind power will be another source of energy. Solar energy — the energy received by the earth from the sun will be an important source of energy. Slowly and gradually, the solar energy will be converted into electricity. As the energy supply becomes scarce, the economy will force the nations so utilize the energy of waste materials. Recycling of materials will gradually become a significant contributor to the energy.

Recycle of waste materials means that all used materials are reused indefinitely. With increasing population, growing economic needs and limited resources and energy crisis, we are definitely moving toward 'recycle society'. In the recycle society, the waste products of home like paper, containers, tin cans, aluminium cans, food scraps and sewage and the waste products of industry like paper, wood, metal scraps will be recycled. Similarly, agricultural wastes, both manure and crop residues will be recycled. Recycling of material will save energy and also the raw material. In a recycle society, the products will be built to be more durable and easily repairable. When a consumer wishes to replace an item for something better or different, he will return the item for standard price. All stores will thus become collection centres as well as selling centres.

Biological warfare is a kind of warfare in which disease-producing germs and their products are used against man, animals, food crops and plants by the enemy. Japanese are said to have used biological warfare agent against China in World War II, and Americans are said to have used these weapons against Korea in Korean War. A number of infectious diseases are used as agents in biological warfare. Some of them are: Anthrax, cholera, dysentary, influenza, plague, pneumonia, tuberculosis, small-pox, cow-pox etc. These agents kill human beings, animals and plants. There is a spread of epidemics in the infected area. There is a danger that in future, biological warfare agents may be used for specific military operations. The agents like those of influenza and plague may be used for reduction of the strongholds of the enemy. Biological warfare agents will be most effective in an underdeveloped country where there is a low level of sanitary and public health facilities.

Chemical warfare is a warfare in which agents like choking gases, vomiting gases, blood gases, nerve gases, incapacitating agents are used against man, animals and plants by the enemy. These gases when dispersed, kill humanbeings, animals and plants. In World War I, 12,000

tons of mustard gas caused 400,000 casualties. Napalm and other chemical agents have in the recent past played havoc in Vietnam. There is a possibility that these gases may be used for specific military purposes in future.

Dr. Watson and Crick received Nobel Prize in 1962 for describing the DNA molecule. Since then, new investgations in genetics have been made. These investigations have offered the possibility of synthetic production of life. In the years to come, it will be possible for a man to make biological carbon copies of himself. This process is known as 'cloning'. Dr. Hafez forecasts that within ten years, a woman will be able to buy a tiny frozen embryo in the store, have it implanted in her uterus, carry it for nine months and then give birth to it as though it has been conceived in her own body. Further, it will be possible to do away with female uterns altogether. Reproduction can take place outside the human body. This will shake the concept of motherhood. The concept of parenthood also will undergo revision. It will be possible for a child to have more than two biological parents.

EXERCISES

1. Explain the term 'futurclogy'. What are its possible applications?
2. Discuss the problem of education in the technological society of the future.
3. What kind of education will be necessary in the future?
4. What will be the effect of automation on society? Will it increase unemployment?
5. Who will hold power in the future society?
6. Will scarcity be put to an end in the future technological society?
7. What are the prospects for the conquest of outer space?
8. What is 'nuclear holocaust'?
9. How will the energy needs be tackled in the future society?
10. What is recycle? What will be the characteristics of a 'recycle society'?
11. What are the prospects for biological warfare?
12. What is chemical warfare? Will chemical warfare agents be used in future warfare?
13. What are the prospects for the 'synthesis of the life'?
14. What do you think, is the future of technological society?

FOUNDATION COURSE Paper—II
(SCIENTIFIC METHOD, SCIENCE, TECHNOLOGY AND DEVELOPMENT)
MAY 1979

SECTION I

Marks

1. (a) Explain the nature of science. 10

(b) Discuss the principles of uniformity of nature and simplicity as presuppositions of science. 10

Or

1. (a) Explain the terms "order" and "system". How does a scientific system differ from a system of mathematics? 10

(b) How do social sciences differ from natural sciences? Why are social sciences less developed than physical sciences? 10

2. (a) Describe the various stages in the scientific method. 10

(b) Bring the role of simple enumeration in scientific investigation. 10

3. (a) Explain and illustrate positive analogy, negative analogy and neutral analogy. 10

Or

3. (a) What is the role of abstraction and generalization in science? 10

(b) Describe the purposes served by models in science. 10

4. (a) What is hypothesis? Explain the main requirements of a good hypothesis. 10

(b) How is a hypothesis established? 10

Or

4. (a) What is the role of hypothesis in science? 10

(b) Can a scientific theory be conclusively falsified? 10

5. (a) Explain the characteristics of scientifie knowledge. 10

(b) Bring out the objective, self-corrective and tentative nature of scientific knowledge. 10

SECTION II

6. (a) Discuss the role of science and technology in the detection, treatment and prevention of diseases. 10

Or

(a) State and explain the modern methods of dealing with mental disorders. 10

Marks

(b) Write notes on any *two* of the following: 10

(i) Air, water and food pollution.

(ii) Use of modern techniques in food production and its preservation.

(iii) Role of chemical technology in modern life.

7. (a) What role do radio and cinema play in economic and cultural life? 10

(b) What is the role of mechanised transport system in modern life? 10

Or

7. (a) Describe the social and economic changes brought about by electricity? 10

(b) How has industrialisation affected the family and community life? 10

8. (a) Discuss whether science has brought about any changes in social attitudes in respect of— 10

(i) Caste-system,

(ii) Physically and mentally handicapped persons.

(b) What is the contribution of technology towards the emancipation of women? 10

Or

8. (a) Discuss to what extent science is responsible for changing the attitude of people to human values. 10

(b) Write a note on the limitations of science and technology. 10

9. (a) Describe the salient features of modernisation and state how modernisation differs from westernisation. 12

(b) Bring out the impediments to the modernisation of India. 8

10. Explain the term futurology. What problems do futurologists envisage about: 20

(i) food supply,

(ii) energy needs,

(iii) industrial raw materials, and

(iv) environmental Pollution.

Or

10. Write notes on any four of the folowing: 20

(i) Nuclear energy for peaceful purposes.

(ii) Waste recycling.

(iii) Biological warfare.

(iv) Science and superstition.

(v) Space travel.

(vi) Green revolution in India.